THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

ART. XIV.—*On Mineralogical Nomenclature;* by JAMES D. DANA.

No. I. *On System in Mineralogical Nomenclature.*

MINERALOGICAL nomenclature had already a commencement of system among the old Greeks and Romans; and this system was the same as that of the modern science. It consisted in adding to the word signifying a quality, constituent, use, or locality of the stone, the termination *ites* or *itis;* and although, through the many ways in which names were originated and the absence of any scientific purpose, those of other kinds are numerous, this was the common method of forming names for objects in inorganic nature.

The following are a few examples, from Pliny's Natural History.

1. *Names derived from physical characters.*

Hæmatites, from *ἅιμα*, *blood*, in allusion to the color of the powder.
Steatites, from *στέαρ*, *fat*, in allusion to the greasy feel.
Pyrites, (including millstones, as well as our pyrites, etc.) from *πῦρ*, *fire*, because supposed to have a peculiar affinity for fire, as shown by the sparks given out when struck.
Rhoditis, from *ῥοδον*, *a rose*, in allusion to the color.
Chloritis, from *χλωρός*, *green*, in allusion to the color.
Ceramitis, from *κέραμος*, a tile, or earthenware, from the color.
Ceritis, from *κηρός*, *wax*.
Iritis, from rainbow-like reflections.
Phengites, from *φέγγος*, *brightness*, in allusion to the transparency.
Selenitis, from *σελήνη*, *the moon*, in allusion to its reflections.
Molochitis (our Malachite) in allusion to its green color, from the Greek for the Mallow.

Porphyrites, from *πορφύρα, purple.*
Prasites—*πρασίτης* of Theophrastus, from the leek-green color.
Crateritis, from *κρατερός, strong,* in allusion to the hardness.
Anthracitis, for a stone resembling coal in being black and yielding a black color when rubbed on a whetstone; also for another kind which resembled a burning coal.
Ophites, for stones having streaks of green color, like serpents.

2. *Names having reference to the form of the stone.*

Ostracites, for fossil shells.
Ostritis, a fossil oyster shell, or related species.
Phenacites, for stones resembling a date.
Botryites, " " a bunch of grapes.
Phycites, " " a seaweed, from *φυκος, a seaweed.*
Scorpitis, " " a scorpion in color or shape.
Dendritis, " " a tree.

3. *Names derived from the uses of the mineral.*

Alabastritis, for the stone (mostly, if not wholly, stalagmite) from which the kind of vase called *alabastron* was made.
Chrysites, from *χρυσός, gold,* it being used in trials for gold.
Basanites, from *βάσανος, a touchstone.*

4. *Names having reference to the constitution of the stone.*

Chalcitis, from *χαλκός, copper* or *brass,* for a copper ore.
Sideritis, from *σίδηρος, iron.*
Chrysitis (from the Greek for *gold*), Argyritis (from the Greek for *silver*), and Molybditis (from the Greek for *lead*), were names of products obtained in the reduction of silver ores; the first is supposed to have been a yellow litharge.

5. *Names derived from the names of localities.*

Pharanites, from the name of a locality in Arabia.
Syrtites, from a locality on the shores of the Syrtes.
Choaspitis, from a locality on the river Choaspes.
Syenitis, from Syene, in Egypt—probably the red Syenite of Syene.
Memphites, from Memphis in Egypt—a kind of marble.

The termination *ites* or *itis* was thus distinctive of the names of minerals, stones, or fossils.* Moreover, the names were derived from qualities, forms, uses, and localities, or from the same characteristics that are now referred to in making the new names of the science. The only modern kind of name not in vogue in Pliny's time is that *after persons.*

Werner appears to have been the first to introduce this class of names into Mineralogy. The earliest example, if I mistake not, was that of naming what de Born had called *Green Mica* (Mica viridis) *Torberite,*

* This termination does not come from the Greek word *λίθος, stone,* for this word when in composition retains in Latin names (and also in the modern German) its original form, as in *Chrysolithus.*

after its investigator, the chemist Torber Bergmann (more correctly written *Torbernite* by some mineralogists of last century, as Bergmann, wrote his name in Latin, the language of his scientific works, Torbernus Bergmann). The name encountered objections; and Werner, in view of Bergmann's announcement (after some incorrect trials) that the mineral was a *copper* ore, substituted in 1789 the name *Chalcolite*. He however, immediately afterward (early in 1790) showed that he saw nothing bad in the style of name by designating other new species *Prehnite* and *Witherite*, the former after Col. Prehn the discoverer, and the latter after Dr. Withering the discoverer and analyst of the species. The same year, Estner, a mineralogist of Vienna, issued a pamphlet against the Werner school, with the title "Freymüthige Gedanken über Herrn Inspector Werner's Verbesserungen in der Mineralogie," etc., (64 pp. 16mo, 1790), in which he makes light of Werner's labors in the science, and under the head of *Prehnite* ridiculed this method of creating a paternity, and providing the childless with children to hand down their names to posterity (p. 25). Such names were, however, too easily made, too pleasant, as a general thing, to give and receive, and withal too free from real objection, to be thus stopped off, and they have since become numerous, even Vienna contributing her full share toward their multiplication.

As a part of the history of mineralogical nomenclature, it may be here added that Werner, when it was proved that his *chalcolite* was an ore of uranium with but little copper, instead of a true ore of copper, dropped the name entirely, and called the mineral simply *Uranglimmer* (Uranium mica); and Karsten, in his reply to Abbé Estner (Berlin, 1793, 80 pp. 12mo), makes out of the necessary rejection of chalcolite an argument against chemical names, and in favor of names after persons, as the latter could never turn out erroneous in signification.

During the Middle ages many provincial names for stones and ores originated, or came into use, in the mining regions of Europe; and some of these have since had general acceptance, such as Quartz, Blende, Hornblende, Talc, Feldspar, Schorl, Mispickel, Copperas (from Kupferwasser of the Germans, like Couperose of the French*).

In the course of the last century, when the science of minerals was taking shape, and progress in chemistry was helping it forward, there was an effort, on one side, to introduce, under the influence of Linnæus, the double names of other branches of Natural History; and, on the other, under the influence of Cronstedt and Bergmann, names expressive of chemical composi-

* The German word Kupferwasser, literally signifying Copper-water, (the *Chalcanthum*, and *Atramentum sutorium* of Pliny,) included the different vitriols, whether in solution or crystallized, which are a common result of the alteration of copper and iron pyrites and blende. Both the copper and iron pyrites passed for copper ores among the older miners from the Greeks down, and they occur mixed together along with blende in most mining regions. The words *couperose* and *copperas* have been supposed to come from the Latin *cuprirosa*. But *cuprum* gave *cuivre* to the French, and it is hardly a possibility that the Latin *u* should in another case, or ever, have become changed to the French *ou* instead of the sharp *u*; while the German *u* would naturally take this form.

tion as far as it was ascertained; and the two methods have had their advocates till late in the present century. But, at the same time, the necessity of single names was recognized by most of the early mineralogists; and in the spirit of the system which had made its appearance among the Greeks and Romans out of the genius of the Greek language, they almost uniformly adopted for the new names the termination *ite*.

Thus we have from Werner the names Torberite, Chalcolite, Graphite, Prehnite, Witherite, Boracite, Augite, Pistacite, Pinite, Aragonite, Apatite, Leucite, Cyanite (Kyanite); and from other sources in the same century, Zeolite, Actinolite, Tremolite, Coccolite, Arendalite, Baikalite, Melanite, Staurolite, Lepidolite, Cryolite, Chiastolite, Collyrite, Agalmatolite, Sommite, Moroxite, Pharmacolite, Strontianite, Delphinite, Titanite, Ceylanite, Gadolinite, Rubellite, Sahlite, Wernerite, Scapolite, Mellite, etc.

The termination *ine*, was also adopted for a few names, as Tourmaline, Olivine, Mascagnine, Serpentine; and *an* in Vesuvian; but the great bulk of the names were systematically terminated in *ite*.

With the opening of the present century (in 1801), Haüy came forward with his great work on Crystallography, and in it he brought out a variety of new names that defy all system, having nothing of the system of the earlier science, and no substitute of his own. Forgetting that the unity of law which he had found in nature should be a feature of scientific language, he gave names to minerals as a gardener might to his varieties of pinks and roses, introducing thus the terminations—

ane, in Cymophane;
ase, in Euclase, Idocrase, Anatase, Dioptase;
aste, in Pleonaste;
age, in Diallage;
ene, in Disthene, Sphene;
gene, in Amphigene;
ide, in Staurotide;
ime, in Analcime;
ole, in Amphibole;
ome, in Aplome, Harmotome;
ose, in Orthose;
ote, in Actinote, Epidote;
yre, in Dipyre;
ype, in Mesotype.

And the true mineralogical termination *ite* he admitted only in the few following: Axinite, Meionite, Pycnite, Stilbite, Grammatite.

Haüy had commanded so great and so general admiration by his brilliant discoveries in crystallography, and by the benefits which he had thus conferred on mineralogical science, that

his names with their innovations were for the most part immediately accepted even beyond the limits of France, although a number of them were substitutes for those of other authors.* Some of Werner's names were among the rejected; and a break was thus occasioned between German and French mineralogy, which will not be wholly removed until the rule of priority, properly restricted, shall be allowed to have sway.

Beudant succeeded Haüy, and had the same want of system in his ideas of nomenclature. Finding occasion to name vari-

* The *substitutes* among the above names in the 1st edition of Haüy's Crystallography (1801) are the following;

Amphibole, for *Hornblende* of last century and earlier.

Orthose, for *Feldspar.*

Pyroxene, for *Augite* of Werner, and *Volcanite* of Delamétherie. [Delamétherie was a contemporary of Haüy at Paris, the author in 1792 of an edition of Mongez's *Manuel du Minéralogiste* (after Bergmann's Sciagraphia); in 1797, of an ambitious speculative work entitled *Théorie de la Terre*, the first two volumes of which consisted of a Treatise on Mineralogy; in 1811, 1813, of *Leçons de Minéralogie*, in 2 vols., and for a number of years principal editor of the *Journal de Physique.* He gave offense to Haüy by some of his early publications. Haüy's mineral Euclase is described in full by Delamétherie in the *Journal de Physique* for 1792 (some years in advance of Haüy's description of it,) without crediting the name or anything else to Haüy: but five years later, in his *Théorie de la Terre*, he inserts the species with full credit to Haüy.]

Cymophane, for *Chrysoberyl* of Werner.

Idocrase, for *Vesuvian* of Werner.

Pleonaste, for *Ceylanite* of Delamétherie.

Disthene, for *Kyanite* (Cyanite) of Werner.

Anatase, for *Octahedrite* of de Saussure, and *Oisanite* of Delamétherie.

Sphene, for *Titanite* of Klaproth.

Nepheline, for *Sommite* of Delamétherie.

Triphane, for *Spodumene* of d'Andrada.

Amphigen, for *Leucite* of Werner.

Actinote, for *Actinolite* of Kirwan, and *Zillerthite* of Delamétherie.

Epidote, for *Thallite* of Delamétherie, *Delphinite* of de Saussure, and *Arendalite* of Karsten.

Axinite, for *Yanolite* of Delamétherie.

Harmotome, for *Andreolite* of Delamétherie.

Grammatite, for *Tremolite* of Pini.

Staurotide, for *Staurolite* of Delamétherie, and *Grenatite* of de Saussure.

And, later, *Paranthine*, for *Scapolite* of d'Andrada, and *Rapidolite* of Abildgaard.

Part of the changes were made with good reason. But others were wholly unnecessary. Haüy was opposed to names from localities, and hence several of the displacements. He objected also to names based on variable characters, and characters not confined to the species. Moreover, as his pupil, Lucas, observes (in giving reasons for rejecting the name *Scapolite* and substituting *Paranthine*,) "le vice du mot *lite*, qui s'applique à toutes les pierres, ne pouvoient plus convenir à cette substance du moment où elle seroit reconnue pour une espèce." Haüy's own names are remarkable, in general, for their indefiniteness of signification, which makes them etymologically nearly as good for one mineral as another, and very bad for almost none; as for example, *Diallage*, which is from the Greek for *difference; Analcime*, from *weakness* in Greek; *Orthose*, from *straight* in Greek; *Epidote*, from *increase* in Greek; *Anatase*, from *erection* in Greek, interpreted by him as equivalent to *length; Idocrase*, from *I see mixture* in Greek, etc. His name *Pyroxene*, which he defines *hôte ou étranger dans le domaine du feu*, is an unfortunate exception, as often remarked, the mineral being the most common and universal constituent of igneous rocks. It was a bad substitute for *Volcanite* of Delamétherie, and looks as if Haüy's adoption of it might have been prompted by repugnance to Delamétherie.

ous mineral species which till then had only chemical names, he adopted Haüy's method of miscellaneous terminations, but indulged in it with less taste and judgment, and with little knowledge of the rules of etymology. In his work we find the termination *ese*, in Apherese, Aphanese, Neoctese, Acerdese, Mimetese; *ise*, in Leberkise, Sperkise, Harkise, (only German words Gallicized,) Melaconise, Zinconise, Crocoise, Stibiconise, Uraconise; *ose*, in Argyrose, Argyrythrose, Psaturose, Aphthalose, Rhodalose, Siderose, Elasmose, Exanthalose, Cyanose, Melinose, Disomose; *ase*, in Neoptase, Discrase; *ime*, in Ypoleime; *ele*, in Exitele; while names ending in *ine* are greatly multiplied.

With a little better knowledge of classical rules he would not have retained the terminal *s* of the Greek in the derivative, and thus have made the intolerable names above which end in *ose* and *ese*, and in part in *ise* (as *Siderose* from σίδηρος, *Aphanese* from ἀφανής, *Melaconise* from μέλας, *black*, and κόνις, *powder*); and with more of the spirit of system, he would have rejected entirely the plan of miscellaneous terminations.

In Germany, the tendency has always been to uniformity through the adoption of the termination *ite*. Breithaupt has been somewhat lawless, giving the science his Plinian, Alumian, Sardinian, Asbolan, etc.; his Castor and Pollux (no doubt regarded as a good joke, though in our view a joke out of place); his Glaucodot, Homichlin, Orthoclase, Loxoclase, Xanthocon, etc.; still, far the larger part of his numerous names are rightly terminated.

In view of the above and other considerations, we arrive at the following conclusions:—

1. The only chance for uniformity in mineralogical nomenclature is in the general use of the termination *ite*.

2. This termination is the best that is available, because of (1) its original use and signification, (2) its early origin, (3) its almost universal adoption in the science.

3. If any other termination in addition is to be used, it should be so only *under system;* that is, it should be made characteristic of a particular natural group of species, and be invariably employed for the names in that group; and its use should not be a matter of choice or whim with describers of species.

As a matter of fact, *ine* has not been employed for any particular division of minerals, or with reference to any system, and it could not now be so restricted; and, this being the case, it should be put out of the science as far as possible. It belongs by adoption and long usage to chemistry, and should be left to that science.

4. In order that the acquired uniformity may be attained, changes should be made in existing names, when it can be done without great inconvenience.

Names like *Quartz*, *Garnet*, *Gypsum*, *Realgar*, *Orpiment*, with the names of the metals and gems, which are part of general literature, must remain unaltered. *Mica* and *Feldspar*, equally old with Quartz, have become the names of *groups* of minerals, and are no longer applied to particular species.

Fluor was written *Fluorite* last century by Napione. *Blende*, although one of the number that might be allowed to stand among the exceptions, has already given place with some mineralogists to *Sphalerite*, a name proposed by Haidinger (because blende was applied also to other species) in 1845, and signifying *deception*, like Blende. Galena was written *Galenite* by von Kobell some years since. Orthoclase, Loxoclase, Oligoclase might be rightly lengthened to *Orthoclasite*, etc. But the termination *clase* (from the Greek for *fracture*) is peculiar to names of minerals, and the abbreviated form in use may be allowed to stand for species of the Feldspar group. It seems better that it be avoided elsewhere. These remarks on special cases might be further extended; but it is unnecessary as I shall soon present my views more fully in another place.

There are of course objections to all such change. But the number of names requiring it are comparatively few; and hardly any of them are over sixty years old—a short time compared with the future of the science. Mineralogy is yet in its formative period; it is far from being so stiffened with age as not to admit of progress in the direction contemplated.

It has become very desirable that the nomenclature of rocks should have some point of difference from that of minerals. Names, like Diorite, Dolerite, Eurite, Porphyrite, Andesite, Tonalite, Phonolite, Leptynite, Domite, Dunite, Amphibolite, Pyroxenite, Pegmatite, Hyperite, Itacolumite, Spilite, Ditroïte, Sanidinite, Phthanite, Nephelinite, Miascite, Itabirite, Aphanite, are fast multiplying, and have nothing in them to indicate whether they are to be looked for or not in a work on mineralogy. It is, therefore, here suggested, as an easy method of giving the names of rocks a distinctive feature, to substitute for *i* in the final *ite* the letter *y*. Thus Diorite, Eurite, Tonalite, etc. would become Dioryte, Euryte, Tonalyte, etc. The *y* is already in the name *Trachyte*. The change would not be necessary in the familiar names Granite and Syenite. In the German language the terminal syllable *lite*, when from the Greek λιθος, is written *lith*, as in *Phonolith*; but it would be no disadvantage to the language, or to its science, if the *h* should be left off here as elsewhere, and the *yte* (or *yt* in German) be accepted as simply a termination in obedience to system.

In another paper I propose to discuss the bearing and limitations of the law of priority in mineralogical nomenclature.

ART. XV.—*Observations and Experiments on living Organisms in heated water;* by JEFFRIES WYMAN, M.D., Hersey Professor of Anatomy in Harvard College.

IN a former number of this Journal (vol. xxxiv, July, 1862), an account was given of some experiments on the formation of Infusoria in boiled solutions of organic matter, the result of which was, that such solutions, exposed only to air which had passed through iron tubes heated to a redness, became the seat of infusorial life. The same result followed when similar solutions were enclosed in hermetically sealed flasks, and subsequently exposed to the action of boiling water. In a few instances Infusoria appeared when the temperature was raised above 212° F. All living beings found under the above circumstances have been attributed either, 1st, to organisms or the germs of them, supposed to be contained in the fluid experimented with, or the air included in the flasks; or 2d, to the direct transformation of organic matter into new living beings, independently of any germs or living organisms whatever; or in other words to "spontaneous generation."

Abundant proof has been brought forward to show that the spores or germs of infusoria exist in the air in quantities amply sufficient to account for the presence of living organisms in solutions freely exposed.

There can therefore be no certainty of the existence of spontaneous generation in a given solution, until it can be shown, that this has been freed of all living organisms which it contained at the beginning of the experiment, and kept free of all such from without during the progress of it. On the other hand, this kind of generation becomes probable, whenever it is made certain that Infusoria do appear in solutions, in which the conditions just mentioned have been complied with.

We say probable, because their appearance under such circumstances would not amount to a proof. The absolute proof of spontaneous generation must come from the formation of living organisms out of *inorganic* matter. If infusoria are generated in solutions of organic matter, independently of spores or germs, the question may be fairly raised whether we do not begin the experiment with materials in which life already exists, even though this material is not in the form of distinct organisms.

The issue between the advocates and the opponents of this doctrine, clearly turns on the extent to which it can be proved that living beings resist the action of water at a high temperature, or on what Pouchet calls "vital resistance," for in nearly all the observations hitherto made, heated water has been the agent for the destruction of infusorial life preliminary to the beginning of an experiment.

The observations and experiments contained in this communication, have not been brought together either for sustaining or refuting the doctrine just referred to, but partly with the view of testing the accuracy of the experiments formerly made, and chiefly for the purpose of determining how far the life of certain kinds of low organisims is either sustained or destroyed in water which has been raised to a high temperature, a result which must be reached before spontaneous generation can be either asserted or denied. The evidence which will be adduced is derived from the following sources:

1st, from the phenomena of hot springs;

2d, from the appearance or non-appearance of Infusoria in solutions boiled for different periods of time, and exposed only to pure air;

3d, from the observed action of heat on the living organisms which the solution experimented with, was known to contain.

SECTION I. *Thermal Springs.*—The study of organisms living in thermal waters is of great importance in connection with the investigation of the limit of vital resistance. Having become adapted, through a long series of years, to their surroundings, such organisms may be supposed to live under circumstances the most favorable possible, for sustaining life at a high temperature. It is a well known physiological fact that living beings may be slowly transferred to new and widely different conditions without injury; but if the same change is suddenly made they perish. In the experiments made in our laboratories, the change of conditions is relatively violent and therefore liable to destroy life by its suddeness, when otherwise it might possibly have been sustained. In the thermal waters therefore which give us a range of temperature as high as 212° F., we are more likely to find the highest degree of heat consistent with the maintenance of life than in our flasks. The following accounts from different observers have been selected as giving the highest temperature at which life has been noticed in hot springs. It must not be overlooked, however, that these have been thus far very imperfectly studied, especially with regard to the lowest organisms, and that we are by no means sure that the extreme limit of endurance in them has been ascertained.

Hot Springs of Luzon.—These springs were examined by Sonnerat* and his account of them is often quoted as evidence that they are inhabited by fishes and plants at a temperature of 187° F.† This assertion is not sustained by those who have visited them since Sonnerat. Dr. Abel who accompanied Lord Amherst in his mission to China examined them, and "saw no fish, but a

* Journal de Physique, Avril, 1774, t. iii, p. 256.

† Spallanzani Opuscoli, Milano, 1826, p. 69.

small snake and a frog which were not only dead but boiled."* Marion de Procé, who has examined the same springs with care states that the waters where the fish were actually found did not exceed 36° C. (or 96·8° F.)* Prof. James D. Dana, one of the naturalists of the U. S. Exploring Expedition also visited them; he makes no mention of animal life, but gives the important observation "that the stones were covered with a white incrustation which appears to be silicoeus, and a species of feathery vegetation occurs also upon those bordering the streamlets where the temperature is 160° F., and presenting various shades of green and white.†"

Hot springs of the Ouachita.—These are situated in Hot-spring Co., Arkansas, and the four hottest are stated by Major Long to have the temperature of 132°, 140°, 148° and 150° F., respectively. He says "not only Confervæ and other vegetables grow in and about the hottest of them, but great numbers of little insects are constantly seen about the bottoms and sides." "A small bivalve testaceous animal adheres to the plants and lives in such a high temperature."‡

Hot springs of Sorujkund.—Dr. Joseph D. Hooker found in these springs *Confervæ* which Berkeley referred to the genus *Leptothrix* "growing on the margins of the tanks and in the hottest water; the brown is the best salamander, and forms a belt in deeper water than the green; both appear in luxuriant strata, wherever the temperature has cooled down to 168° F., and as low as 90°."§

The hot springs of Pugha, in Thibet reach the temperature of 174° F., and *Confervæ* and *Oscillatoriæ* were found growing in them by Capt. Strachey.‖

Hot springs of Mariara and La Trinchera.—Humboldt has given the result of his own carefully made observations on the thermal waters of South America, among the most remarkable of which are those of Mariara and La Trinchera, and of these the latter is the hottest. Of La Trinchera he says, "We were surprised at the luxuriant vegetation that surrounds the basin; *Mimosas* with slender pinnate leaves, *Clusias* and fig trees have pushed their roots into the bottom of a pool, the temperature of which was 85° C. (185° F.), and the branches of these trees extend over the surface of the water at two or three inches distant." "An *Arum* with a woody stem, and with large sagittate leaves, rose in the very middle of the pool, the temperature of which was 70° C. (158° F.) Plants of the same species vege-

* Edwards, Influence of Physical Agents on Life. Translated by Dr. Hodgkin and Dr. Fisher. London, 1832, p. 466.
† Geology of the U. S. Exploring Expedition, p. 543.
‡ Long's Expedition to the Rocky Mountains, vol. ii, p. 291. Philadelphia, 1822.
§ Himilaya Journals, vol. i, p. 27. London, 1854.
‖ Ibid, vol. ii, p. 379.

tate in other parts of those mountains at the brink of torrents, the temperature of which is not 18° C. (64·4° F.)*

Hot springs of California.—I am indebted to Dr. William H. Brewer, Botanist to the Geological Survey of California, and to Mr. William T. Brigham of Boston for the information which follows, in relation to the thermal waters of this state which they have personally examined. Dr. Brewer's observations as will be seen by the following extract from his letter to me, show the existence of plants in water of a considerably higher temperature than even that of La Trinchera. He says, "the place where the greatest temperature was noticed, in which plants occur is the Geysers, in Lake (formerly Sonoma) county about seventy-five miles north of San Francisco. Vegetable forms flourished in these waters at various temperatures up to 93° C., (199·6° F.,) but were most abundant in waters of the temperatures of 52° to 55° C. (125°–131° F.)"

"At the higher temperature they were not abundant and existed as grains like Nostoc or Protococcus, intensely green and rather dark. They were observed in several cases where the water was above 90° C., but were more common in the streams, as the water cooled, and formed large slimy masses. Much of these were in long slender filaments like Confervæ."†

"The temperatures given here were carefully observed with a standard centigrade thermometer, with a naked elongated bulb."

Mr. Brigham visited the same springs and made a collection of some of the Confervoid plants growing in them. In regard to animal life he says, "although I looked with great care I could find no living animals in the water, but boiled insects were rather common. These were not fair cases, as the waters were so strongly impregnated with sulphur and acid that these alone might account for the absence of animal life. On the bank where the temperature ranged from 197° to 207° F., spiders were abundant and seemed to feel no inconvenience from the heat. I saw several feeding on the bodies of insects boiled by the water. The spiders were seen even standing on the water which was 176° F.; their bodies were not immersed and the hairs on the legs might, as is often the case, repel the water."

Hot springs of Iceland.—"Mr. Flourens exhibited to the Academy, Confervæ collected in Iceland by M. Descloizeaux who found them growing in the Gröf at a temperature of 98° C., or 208° F."‡

Many other accounts§ of living organisms in thermal waters

* Personal Narrative, Bohn's edition, London, 1852, vol. ii, p. 88.

† Since the above was written. Prof. Dana and Dr. Brewer have published in this Journal, 1866, vol. xli, p. 389, various observations and remarks in relation to life in hot springs and in high temperatures.

‡ Comptes Rendus de l'Academie des Sciences, xxiii, 1846, p. 934.

§ See Edwards, Influence of Physical Agents on Life, London, 1832, p. 407. Carpenter, Gen. and Comp. Physiology, Philadelphia, 1851, pp. 57 and 70.

might be given, but they relate mostly to a temperature lower than that of those already mentioned. Our object has been to bring together only the hottest, and with regard to which the evidence is trustworthy.

The statements we have quoted give satisfactory proof that different kinds of plants may live in water of various temperatures, as high as 168° F., as observed by Dr. Hooker in Sorujkund, 174° as observed by Capt. Strachey in Thibet, 185° as observed by Humboldt in La Trinchera, 199° as observed by Dr. Brewer in California, and 208° as observed by Descloizeaux in Iceland. The lowest forms only are found in the hottest waters.

With regard to animals the testimony is much less complete. The highest temperature at which they have been found, in so far as we have seen any evidence was, as stated by Major Long, 150° F., in the hot springs of the Ouachita where he found "bivalve testaceous animals" and insects. In the instance mentioned by Mr. Brigham, although the spiders were in air the temperature of which was from 197° to 207° F., it is doubtful whether their bodies were as hot. They are air-breathing animals, but it is not unlikely that the heat of their bodies is kept down as in others whose breathing is aerial by the evaporation from their respiratory and other surfaces. Otherwise it does not appear how the albuminous matter in their fluids is kept from coagulation. When walking on the surface of the water it is most probable, as Mr. Brigham suggests, that their feet are not immersed, but that these, as in Hydrometro, repel the water; the insects therefore might be wholly surrounded by air, in which case the temperature would be lower than that of the water. If a thermometer be held a short distance, not exceeding a half-inch, from the surface of boiling water, the temperature indicated will be many degrees below the boiling point. A marked difference exists even when the bulb and water nearly touch.

To show the importance of great accuracy in determining the temperature at the precise spot where the organisms are found we will cite the following statement, where a very erroneous result would have been obtained if the temperature of the surface-water had been taken as representing that of the whole mass. Tripier in his account of the baths of Hamman-mes-Koutin, in Algeria, saw fishes in water the surface of which had a temperature of 56° C. (132° F.), but in the lower layers from which the fishes did not rise, the thermometer indicated only 40° C. (104° F.) It is to be feared that this possible difference of temperature has not always been kept in view, by those who have reported the existence of animals in water of a high degree of heat.

Dr. Carpenter in his General and Comparative Physiology mentions several instances of animals living in a high temperature and also states, that "at the island of New Amsterdam there is a mud spring, which, though hotter than boiling water, gives birth to a species of Liverwort."* It is presumed that this is the island of the same name referred to by Humboldt, but he only states that the springs in question were much hotter than those of the Mariara, which last were from 132° to 135° F.† It has also been asserted that Humboldt saw living fishes thrown out from the crater of Chimborazo at 210° F., and that they have been discharged at a higher temperature from the Geysers of Iceland.‡ In the first instance it was at Cotopaxi and not Chimborazo, that Humboldt made his observations. A species called *preñadillas* by the natives (*Pimelodus cyclopum*) is expelled from time to time from the crater, or clefts in the sides of it, in immense numbers; but he expressly states that the water expelled at the same time is not hot but cold and that the fishes are not so disfigured as to indicate that they had been exposed to a high temperature.§ We have not been able to find authority for the statement with regard to the Geysers.

Section II. *Experiments with boiled solutions of organic matter in sealed flasks.*—These experiments, which are divided into two series, were made for the purpose of ascertaining to what extent certain kinds of organic solutions became the seat of infusorial life, notwithstanding a more or less prolonged exposure to boiling water, and the precautions taken to exclude the entrance of infusoria from without. They are in part repititions of some of those formerly described, the results of which they fully confirm. Great pains have been taken to ensure accuracy in conducting, as well as in observing and recording them.‖

* Gen. and Comp. Physiol., 3d edition, Philadelphia, 1851, pp. 57 and 70.

† Humboldt's Personal Narrative, London, 1852, vol. ii, p. 24.

‡ Bibliothèque Universelle de Geneve, tome xx, p. 204, 1839.

§ Humboldt, Recueil d'Observations de Zoologie et d'Anatomie Comparée, 4to. Paris, 1811, p. 21.

‖ M. Milne Edwards in referring to the former series of experiments reported by the writer of this article and to others similar to them, questions their accuracy, since they do not agree with those of M. Pasteur, and thinks the difference in the results depended upon a defective mode of conducting the experiments. The process employed in some of them was identical with that employed by M. Pasteur himself, and in others, with that made use of by M. Milne Edwards in his one experiment (see his *Leçons sur la Physiologie et l'Anatomie Comparèe*, t. viii, pp. 260, 269.) When flasks, holding organic fluids and air, are hermetically sealed and boiled for from fifteen minutes to three or four hours, and infusoria make their appearance nevertheless, the experiment cannot be called a faulty one, so long as only these results are claimed. The recent experiments of Dr. G. W. Child of Oxford, England, and those reported in this communication are a sufficient answer to the criticisms of M. Edwards. The experiment of Pouchet recorded in his *Nouvelles Experiences*, Paris, 1864, p. 224, is conclusive as to possibility of Infusoria appearing in boiled solutions exposed to pure air.

Series A. The flasks used in this series had a capacity of about 800 c. c. and had a long and slender neck; this was drawn out, about an inch from the end to a size which could easily be melted in a flame and in some instances the stem of a clay pipe, with a calibre of 0·08 inch, and in others, a copper tube 0·18 inch in diameter and filled with fine wires, was cemented into the mouth. The fluid in the flasks was boiled and thus the contained air expelled and replaced by steam. After the boiling had been continued sufficiently long, the whole was then allowed to cool slowly, the air to reënter through the tube, which last was kept meanwhile at a red heat. After the flask was cold it was hermetically sealed, the heat of the tube being carefully kept up until this was accomplished. Thus a boiled organic solution was obtained, in contact only with air which had been purified by heat.

Exp. I.—The contents of the flask were a few grains of meat and sugar, and 20 c. c. of water boiled 25 minutes. An infusorial film was formed on the 5th day; the flask was opened on the 31st. Vibrios were found in large numbers.

Exp. II.—50 c. c. of beef-juice and water were boiled twenty minutes. On the 4th day a thick infusorial film was formed over the whole surface of the fluid; the flask was opened on the 6th day and found to contain Vibrios and Bacteriums.

Exp. III.—The flask contained a small piece of beef weighing about three grammes, and 50 c. c. of water, which were boiled 30 minutes. An infusorial film was formed on the 3d day, which sank to the bottom and was afterwards replaced by another.

The flask was opened on the 27th day; the contents had a nauseous odor but were not putrid. The muscular fasciculi had fallen to pieces and the fluid had become slimy and viscid. Immense numbers of Monads filled the solution. Some feathery crystals were noticed, but the most striking circumstance in this as well as in some other instances in which muscle was used, was the fatty degeneration of the fibres which had taken place subsequently to the boiling. The fibres were found in many stages of change, some of them having their contents finely granular, striæ still seen, while others were filled with oil-globules, and had no traces of striæ left. One specimen was examined by Dr. Calvin Ellis who was unable to recognize any difference between the appearances which it presented and those of ordinary fatty degeneration of the muscles.

Exp. IV.—The flask contained very thin wheat paste mixed with saliva and water; the boiling was continued 25 minutes. No film was noticed until the 30th day, the flask was opened on the 68th day, and the fluid found filled with Monads.

Exp. V.—A few grains each of meat and sugar in 20 c. c. of water were boiled 25 minutes. An infusorial film appeared on the 4th day. The flask was opened on the 50th day by Prof. Henry James Clarke by whom the accompanying figures were carefully drawn from nature.

Fig. 1. *Vibrio baccillus*, enlarged two thousand diameters; these are very numerous and move quickly; the joints appear to be united by a gelatinous substance which is quite transparent and move on each other by a series of flexions and extensions; the number of segments is variable.

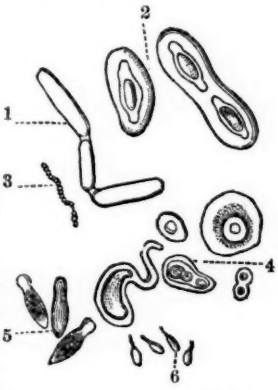


Fig. 2. *Bacterium;* enlarged four thousand diameters. Prof. Clarke has given especial attention to these bodies, and has shown that they are somewhat more complex than generally supposed. They consist of a dark colored oval nucleus, around which is a transparent space, and around this a gelatinous envelope of extreme delicacy. They are sometimes seen single but generally double; more than two are rarely united together.

Fig. 3. A linear series of globules enlarged five hundred diameters; these have the power of locomotion.

Fig. 4. Excessively faint and colorless bodies of great delicacy, and changing their form under the slightest pressure. They closely resemble the substance described by Virchow as *myeline* which not only forms the medullary sheath of the nerves, but is also found abundantly elsewhere. He says "there scarcely exists a tissue rich in cells in which this substance does not exist in large quantities."*

Fig. 5. This figure, also drawn by Prof. Clarke, represents an organism commonly seen in nearly all of the experiments. It is enlarged thirty-five hundred diameters.

Fig. 6, represents the form of the bodies we have called Monads, and each has a ciliated appendage and is locomotive.

SERIES B.—The flasks in which the experiments described below were made, all had the same capacity, viz. about 70 c. c., and the quantity of solution used in each was from 5 to 8 c. c. After the fluid to be experimented with had been introduced they were sealed at the temperature of the room, placed in a covered vessel containing water, and the whole heated to 212° F., and boiled for various periods.

This method corresponds substantially with that of the Need-

* Cellular Pathology, translated by Dr. Chance, p. 234. London, 1860.

ham and Spallanzanni. It is in all respects more simple and easier than that in which the apparatus is complicated with a heated tube. This last beyond a question destroys all organisms contained in the air which enter the flask through it, but is without effect on such as may be contained in the solution, or adhere to the inner surface of the glass. These come in contact only with boiling water or steam, and unless destroyed by one or the other of these, would be sufficient to vitiate any experiment, however careful the adjustment and heating of the tube may have been. We therefore believe that the tube is an unnecessary and useless complication of the apparatus.

Exp. VI.—Six flasks prepared as above, and containing from 5 to 8 c. c. of beef juice and water were boiled 30 minutes. The albuminous matter was coagulated, but the fluid portion became perfectly transparent. The contents became turbid and an infusorial film was formed in four of the flasks on the 7th day, and a few days afterwards in the others.

Exp. VII.—Six flasks, each containing about 1 gram of beef and 5 c. c. of water were boiled 30 minutes. An infusorial film was formed on the surface of all of them on or before the 7th day.

Exp. VIII.—A single flask containing a few grains of finely ground bean flour and 5 c. c. of water was boiled 48 minutes. The mixture became filled with Vibrios on the 4th day.

Exp. IX.—Six flasks containing beef juice and water were boiled 30 minutes. A thick infusorial film was formed in all of them on or before the 7th day.

Exp. X.—Six flasks containing each a few milligrams of beef and 5 c. c. of water were boiled 30 minutes. An infusorial film was formed on all on or before the 17th day.

In the preceding experiments of this series, the boiling was continued thirty minutes in four, and forty-eight in the fifth. The following experiments were made for the purpose of ascertaining whether prolonged boiling would be attended with a different result.

Exp. XI.—Five flasks, each containing a few grains of beef, and about 5 c. c. of water were prepared as in the preceding experiments; one was boiled 32 minutes, one 50 minutes, and the other three 1 hour and 20 minutes each.

An infusorial film formed in the first on the 2d day, in the second on the 6th day, in one of those boiled 1 hour and 20 minutes on the 8th, and in the others on the 10th. All were examined and found to contain *Vibrios* and *Bacteriums;* and in addition the first and second contained the "myeloid substance" already described, fig 4. Those which were boiled longest were the latest in developing infusoria; but of those boiled 1 hour and 20 minutes, they appeared two days later than in the other.

Exp. XII.—Twenty-four flasks each containing about 5 c. c.

of beef juice were divided into six series of four each, and boiled for different periods as indicated in the following table; this table also gives the day of the appearance of the infusoria in each of the flasks belonging to a given series.

Series.	Time boiled.	Day of appearance of Infusoria.			
I.	0^h 30^m	3	4	6	0
II.	0^h 45^m	4	4	4	4
III.	1^h 00	4	4	4	0
IV.	1^h 15^m	4	4	0	0
V.	1^h 30^m	4	0	0	0
VI.	2^h 00	0	0	0	0

Seven of the flasks produced no infusoria, and the number in which they did appear becomes less the longer the boiling was continued.

Exp. XIII.—Of seventeen flasks containing beef-juice eleven were boiled 45 minutes, and 6 were boiled 2 hours. Infusoria appeared in all of the first series except one, at the end of the second day, and in the remaining one of this series and in all of the second on the 3d day.

It will be seen at a glance that Expts. XII and XIII differ in their results, and that of four flasks in Ex. XII boiled 1 h. and 30 m., three produced no infusoria, while in Ex. XIII the infusoria appeared in all, six of which were boiled two hours. We have several times met with similar differences in successive experiments. Sometimes flasks boiled for a single hour became wholly inert, even when the number of them was quite large. We can only insist that in the above experiments the flasks were properly sealed, and that there was no error as to the time for which the boiling was kept up.

Exp. XIV.—Twenty flasks containing extract of beef were treated as follows:

	No. of flasks in each series.	Time boiled.	Day on which infusoria appeared.				
Series I.	5 flasks.	1^h	6	6	6	6	6
" II.	5 "	2^h	6	6	6	6	7
" III.	5 "	3^h	6	0	0	0	0
" IV.	5 "	4^h	0	0	0	0	0

No flask was opened until the sixth day, though there were slight indications of infusoria three days previously; actively moving Vibrios were found in large numbers. The experiment was discontinued on the 10th day, as there was no indication of further change.

Exp. XV.—Thirty-two flasks containing a boiled solution of "extract of beef"* were arranged in six series, and boiled for different times as seen in the following table:

* This is Borden's concentrated juice of beef, evaporated to a nearly solid substance, is free from tissues, and is entirely soluble.

	No. of flasks in each series.	Time boiled.	Day on which Infusoria appeared.				
Series I.	5	$0^h\ 30^m$	1	1	2	2	2
" II.	5	1 00	2	2	2	2	2
" III.	5	1 30	2	2	2	2	2
" IV.	5	2 20	1	2	2	2	2
" V.	5	3 30	2	2	3	3	?
" VI.	7	4 00	2 4	2 4	2	4	4

An infusorial film formed in all the flasks on the days indicated, except in the one marked doubtful in series V, and those of series VI, in which infusoria appeared on the 4th day. None of these last had a film, but, as in the one marked doubtful in series V, had an immense number of minute bodies, which formed a cloud when the flask was shaken, and were not there when the experiment was begun. These bodies were spherical, had an outer wall, and a nucleus which was also a hollow body. They were of different sizes, and seemed to be undergoing multiplication by division. Their real nature must be considered doubtful. The films in the other flasks consisted chiefly of Bacteriums.

The preceding experiments show that if the boiling of the flasks be continued for four hours, as in Exp. XV, the infusoria may appear nevertheless—though in other cases it has happened, as in Exp. XII, that life ceased to be manifested if it was continued only for two hours.

In pushing the experiments still further, we have not found that infusoria appeared in any instance if the boiling was prolonged to five or six hours. Several experiments, in which many flasks were used, were tried, but the result was uniformly the same. Thus a limit to the development of infusoria in boiling water was reached.

Section III. *Experiments to show the effect of boiling water on living infusoria.*—In view of the results given above, viz., the development of infusoria in sealed flasks, notwithstanding the precautions taken, the question naturally arises whether the infusoria which appeared were already in the flask and resisted the action of the water at 212° F. If not, then the invasion of the contents of the flasks by them is easily accounted for, since experiment shows that even a very few individuals if present may multiply so rapidly as to fill and make turbid a given solution in a very short time. But on the other hand, if the infusoria perish during the boiling, then any subsequent appearance of them under the circumstances, must be explained in some other way than by the common process of reproduction.

Since large numbers of infusoria can be proved at all times to be floating in the air, we must assume that some are included in every flask, and since certain organisms live in thermal

waters at a very high temperature, within a few degrees even of boiling water, the experimenter is called upon to show whether water at the boiling point is or is not destructive of life, before he can venture to offer a theory of the origin of the infusoria in the flasks. It should not be overlooked that a marked difference exists between the conditions of life in the flasks and the thermal springs; in the former, the temperature is suddenly raised from that of the air to the boiling point, while in the latter, the organisms inhabiting them have become adapted to their surroundings through long periods of time. Furthermore it must be remembered that in the two cases, we have to deal with widely different species. It therefore becomes necessary to determine by direct experiment on the species of infusoria found in the flasks what *their* powers of resistance are.

Before proceeding to give the result of the experiments we have made, bearing upon this question, we will notice some of the statements which are constantly urged in support of the opinion that infusoria are capable of resisting water of a very high temperature. Among these are the ones relating to the well known experiments of Doyére and others, in which Tardigrades and Rotifers are asserted to have resisted a heat of 248° F. In these cases the important condition that the organism was in a *dry* and not in a moist state is often overlooked. In truth Doyére himself expressly mentions that in a *moist* condition they perished at 122° F.*

In the alleged instances of seeds resisting the action of boiling water, it may be reasonably doubted whether in these the results have not been misunderstood. Spallanzanni clearly proved that if the seeds experimented upon by him were soaked previously to the boiling, they did not germinate.† So long as the water does not penetrate to the germ, this is no more influenced by it than if the germ were exposed to dry air heated to the same degree, and this it easily resists. Water penetrates the seeds of many plants and especially of some of the *Leguminosæ* very slowly; in the case of those of *Gleiditchia* and *Laburnum*, we have found several days and even weeks necessary for the complete penetration of cold water, though when the water is hot it penetrates much more readily. If therefore the seeds are dry when immersed, and are boiled for a few minutes only, they may still germinate. If they are moistened beforehand, the action of boiling water has been found uniformly fatal. In one of our experiments twenty-eight seeds of *Gleiditchia* were soaked

* Annales des Sciences Naturelles, t. xviii, 1842, p. 29. The whole subject as regards the resistance of *dried* Rotifers to heat, was investigated in an exhaustive manner by a commission consisting of Balbiani, Berthelot, Brown Sequard, Dareste, Guillermen and Robin. See Comptes Rendus et Memoires de la Societé de Biologie, 1860.

† Oposcoli, Milano, 1826, p. 63.

until their coverings became soft and swollen; one half were planted at once, and the others after having been boiled five minutes. None of the boiled ones germinated while all the others did. Similar experiments with beans and with several other kinds of seeds ended in a similar manner.

Pasteur has given the result of his own observations on the effects of high temperature on the spores of some of the different kinds of Cryptogams, and states that they resist when dry 248° to 257° F., but perish at 266°.* He gives no experiments in which the spores were exposed to heated water, or to steam. He excuses himself, however, on the ground of being unable to devise a sufficiently rigorous method of experimentation.† We believe the alleged difficulty can be met, and shall endeavor to show by a series of comparative experiments that definite results may be obtained. From the manner in which Pasteur states his own results, he gives the impression that in view of the fact that the spores resist when *dry* a temperature of 257° F., it is reasonable to suppose that they will resist 212° when *moist.* He does not assert this, but leaves his reader to infer it. We have tried many experiments upon different kinds of moulds and yeast plants and have found, as nearly all observers have, that they perish at 212° F. Every one is familiar with the process of "scalding" in domestic economy, which destroys the kinds of cryptogams ordinarily concerned in fermentation, and on the efficacy of which the preservation of canned meats and other articles depends. As regards moulds the following experiment is decisive. Take any number of cups of paste and sow them all freely with spores; put one half in a covered vessel containing a small quantity of water; boil this for a few minutes, thus exposing the paste and spores to steam, and then set all the cups in similar conditions for light and heat; none of the spores in the series which has been steamed will germinate, while all others will.

Payen is quoted by many writers as asserting that the spores of *Oidium aurantiacum* germinated after having been exposed to 248° F. Pasteur himself expresses the belief that in this case the temperature has been erroneously determined.‡ Payen's own statements are somewhat conflicting. In the one most commonly quoted he says that spores heated in ordinary dough to 120° C. (248° F.), may still germinate, but are so altered at 140° C. (284° F.) that they do not germinate.§ In another and later statement he presents the matter quite differently. "The spores of *Oidium,*" he says, "preserve their vegetative faculty in the soft part of the bread, (*la mie du pain*) the tem-

* Ann. des Sc. Nat., t. xvi, 1861, p. 81. † Ibid., p. 85.
‡ Ann. des Sc. Nat., t. xvi, 1861, p. 81.
§ Ann. de Chim. et de Phys., 3me serie, t. xxiv, 1848, p. 254.

perature of which does not exceed 100° C. during the baking;* while in the crust, the temperature which exceeds 200° C. (392° F.) destroyed the vitality of the *Oidium.*"† There are here two conditions of the bread recognized; the moist interior which destroys the spores at 212° F., and the dry exterior which does so at 392° F. Mention has also been made of the germination of seeds taken from the raspberry jam, as proof that these had resisted the action of boiling water. But in none of these cases have we seen any evidence adduced to show that they had really been boiled. We have not been able to find a single instance in which seeds or spores or infusoria, excepting only Vibrios, Bacteriums and Monads, thoroughly moistened before the experiment, have resisted the prolonged action of boiling water.‡

The organisms which we have most commonly met with in our experiments in flasks, in fact almost the only ones, when the boiling was prolonged, are *Vibrios*, *Bacteriums* and *Monads.* The first and second are without doubt plants allied to the *Algæ;* the nature of *Monads* is more obscure. They are all among the lowest of living organisms. Leaving out of consideration ciliated infusoria which perish more easily, our inquiry now is, *at what temperature, or after how long an exposure to the action of boiling water are the Vibrios, Bacteriums and Monads killed, and by what signs can we know that they are dead?*—This question is a difficult one to answer.

The usual signs of life manifested by the infusoria found in the flasks are the following: 1st, locomotion in nearly all of the species; 2d, growth and reproduction; 3d, their reaction on the surrounding fluid, producing fermentation or putrefaction. The second and third are so intimately associated that the presence of one is almost a certain indication of the other. If a clear organic solution ferments, or becomes turbid, it may be safely inferred that living infusoria are present; nevertheless the correctness of this inference must be tested with the microscope. The absence of either of the above signs *alone* cannot be considered as a proof of death, and under certain circumstances all *signs* of life may cease, but the infursoria may still be alive. If for example, they are developed in a sealed flask, as soon as the organic matter convertible into infusoria is exhausted their activity ceases, and they remain dormant for months; we have kept them in this way for a year; but if fresh material is supplied to them, they at once resume their activity. Inactivity *in the presence* of organic material suitable for nourishment, and of

* The baking in this case was for the purpose of destroying the spores in loaves in store, and not for those going into the oven for the first time.

† Precis de Chim. Indust. Paris, 1859, t. ii, p. 150.

‡ The assertion of M. Coste, that encysted infusoria resist the action of boiling water, has been shown to be incorrect by the conclusive experiments of M. Victor Munier.

air at the ordinary temperature, added to the absence of the other signs of life, must be considered as the best indication of death.

1. *Arrest of motion.*—The temperature at which motion ceases was determined as follows: a wide-mouthed bottle containing infusoria was set in a water-bath, and a thermometer suspended with its bulb in the infusorial fluid. The whole was gradually heated, and drops of the fluid were examined from time to time with the microscope, until the motions of the infusoria ceased. The following table gives the result of the examination of fluids taken from several different sources. The movements of the Vibrios lasted longer than those of all other kinds, and the temperature given below is that at which the motions of these were arrested. The motion of all the ciliated infusoria stopped at less than 130° F.

Motion ceased	Experiments. I.	II.	III.	IV.	V.	Average.
	°	°	°	°	°	°
In infusoria from a macerating tub at	57·5	57·0	56·0	57·0	56·0	56·7 C. = 134·06 F.
In infusoria from another tub at	55·0	57·0	58·0	57·0	58·0	56·4 C. = 133·00 F
In infusoria from beef juice at	55·0	54·0	55·0	54·0		54·5 C. = 130·00 F.
In infusoria from a source not stated at	57·0	55·0	56·0			56·0 C. = 132·90 F.

2. *Arrest of growth and reproduction.*—In the following experiments as a matter of convenience the temperature was always carried to the boiling point, though it by no means follows that this was in all cases necessary. The object was to determine by comparative experiments, whether the growth and reproduction of the infusoria and their reaction upon a given solution is arrested or modified by their having been exposed to boiling water. The solution used in nearly all was beef juice,* obtained by grinding up flesh with water, which was poured off, boiled and filtered; it thus became limpid and well adapted to show the slightest change in transparency which attends the development of infusoria. Equal quantities of the solution were poured into a given number of bottles, and these were divided into three series. Those of the *first* were set aside as criteria; to each of those of the *second* was added a drop of water containing active infusoria; to each of those the *third* was added a drop of the same fluid as in the second series, but after it had been boiled. All were placed together, having a similar exposure to light and heat. By a comparison of the results of the second and third series it will be seen whether the boiling has perceptibly affected the growth and reproduction of the infusoria; by a comparison of the results in either the second or third series with those of the first, the difference will be shown between the effect of adding boiled or unboiled infusoria on the

* In some of the later experiments, instead of beef juice prepared as above, a solution of Borden's "extract of beef" was used.

one hand, and the simple exposure of the solution to the air without the addition of either, on the other. When an open bottle was used it was in most cases covered with a paper cap to exclude in a measure the dust from the air; this exclusion was of course incomplete, but as all the flasks were equally exposed and large numbers were used, any disturbance would be the same for all, and might therefore be left out of the account. As will be seen further on we have not depended solely on this form of the experiment.

Exp. XVI.—Eighteen bottles of the capacity of 25 c. c. and an inch in diameter throughout and containing equal quantities of boiled and filtered beef juice were divided into three series of six each. All of series I were set aside as criteria; to all of series II were added from a bottle five drops of water containing large numbers of living Vibrios taken from a fluid in which flesh was macerating; to all of series III were added five drops of the same infusorial fluid after it had been boiled five minutes.

On the 2d day all of series II, to which the unboiled infusoria had been added, were turbid from the rapid multiplication of the animalcules, and an infusorial film was formed on the surface of the fluid. All of series I and III were unchanged.

On the 3d day all of I and III had begun to be turbid, and on the 4th were equally so with II.

Exp. XVII.—Thirty-three bottles prepared and arranged as in the preceding experiment were divided into three series of eleven each.

On the 2d day all of series II were turbid and had an infusorial film. The others were unchanged.

On the 3d day eight of series I and seven of series III had become turbid and the rest became so on or before the 6th day.

From the above experiments it is obvious that the boiling of infusoria has a marked effect, since the solutions, to which boiled infusoria were added, did not become invaded by animalcules sooner than those to which none had been added, while those to which unboiled infusoria were added, were in all cases invaded at least one day and in some, two or three days earlier.

In each of the preceding experiments the bottles were all more or less exposed to the air, for the paper covering was only a partial protection. The following modification of them was tried, for the purpose of ascertaining if there would be any difference in the time in which infusoria would appear in portions of the same solution enclosed in two series of flasks, to one of which infusoria had been added, and all of both series sealed at the temperature of the room, and afterwards boiled for the same time. By performing the experiment in this way the influence of dust from the air was eliminated, excepting in so far as it was present in the flasks at the time they were sealed. This

would be the same in both series, as it was in the preceding experiments, the only difference being that the quantity would be less, and there would be none which had not been boiled.

Exp. XVIII.—Nineteen flasks of about 75 c. c. capacity, each containing about 15 c. c. of boiled and filtered beef juice were divided into two series, one of nine and the other of ten flasks. All of series I were sealed at the temperature of the room, without any addition to their contents. After a drop of water containing active infusoria had been added to each of series II, these were also sealed at the temperature of the room, and then all of both series boiled 15 minutes.

They were allowed to stand twelve days in a cold room in the winter, when no change having taken place they were removed to a room in which the temperature ranged from 50° to 70° F., day and night. Six days later, on the 18th from the beginning of the experiment, five flasks of each series had become turbid, and on the 20th all had become so. There was no obvious difference between the two series in the time required for the development of the infusoria. A longer time passed before the infusoria appeared than in the experiments with the open bottles, but this is to be attributed in part to the coldness of the room in which they were at first placed. But even in the warm room it was six days before they became turbid.

Exp. XIX.—Seven flasks containing boiled and filtered beef juice were divided into two series—I, consisting of three flasks, had added to the above fluid in each one drop of infusorial fluid, and were sealed and allowed to remain at the temperature of the room. Series II consisted of four flasks prepared as in series I, but after being sealed were boiled 30 minutes.

At the end of 18 hours two of series I had become turbid but none of II. At the 25th hour all of I were turbid and two of II. On the 3d day three of II were turbid and on the 4th all were.

Exp. XX.—A fluid was prepared containing half a gram of extract of beef to 100 c. c. of water. Twenty-one flasks containing this fluid were divided into four series.

Series I, consisting of three flasks which were sealed at the temperature of the room.

Series II, consisting of six flasks, had added to each one drop of dust fluid; this last was made by adding three or four grams of dust from the tops of shelves, to about 200 c. c. of boiled water which had cooled; the mixture was shaken, the heaviest particles of dust allowed to settle, and the rest poured off. At the end of a few days this fluid contained active Vibrios.

Series III, consisted of six flasks containing the same as those of series I, sealed at the temperature of the room, and then boiled 30 minutes.

Series IV, consisting of six flasks, contained the same fluid

with the addition of one drop of dust water to each flask; all were boiled 30 minutes.

On the second day one of series I, and all those of II were turbid and had a film—III and IV were unchanged, and perfectly transparent. On the third day infusoria appeared in III and IV, but were confined to the surface, forming a granular looking film, the fluid remaining transparent.

The contents of the flasks were examined with the microscope. I and II contained Vibrois of a large size, some of them extending nearly across the field, and when free moved slowly. III and IV also contained Vibrios, but of a very minute size and moved with great rapidity.

The boiling in the above experiment was followed by a later appearance of infusoria in III and IV than in I and II. The addition of dust water to series II, hastened the development of infusoria. In series IV to which the same dust had been added, but the flask and contents subsequently boiled after being sealed, infusoria appeared one day later.

Conclusions.—The following conclusions appear to the writer to be justified by the observations and experiments recorded in this paper.

1st. In thermal waters plants belonging to the lower kinds of Algæ live in water the temperature of which in some instances rises as high as 208° F.

2d. Solutions of organic matter boiled for twenty-five minutes, and exposed only to air which had passed through iron tubes heated to redness, became the seat of infusorial life. Exps. I–V.

3d. Similar solutions contained in flasks hermetically sealed, and then immersed in boiling water for periods varying from a few minutes to four hours, also became the seat of infusorial life. The infusoria were chiefly Vibrios, Bacteriums and Monads. Exps. VI–XV.

4th. No ciliated infusoria, unless Monads are such, appeared in the experiments referred to in the above conclusions.

5th. No infusoria of any kind appeared if the boiling was prolonged beyond a period of five hours.

6. Infusoria having the faculty of locomotion lost this when exposed in water to a temperature of from 120° to 134° F. Exp. page 172.

7. If Vibrios, Bacteriums and Monads are added to a clear and limpid organic solution, this becomes turbid from their multiplication in from one to two days. If however they have been previously boiled, the solution does not become turbid, until from one to two days later, and in some of the experiments not sooner than does the same solution to which no infusoria have been added.

ART. XVI.—*Remarks on Prof. Geinitz's views respecting the Upper Paleozoic rocks and Fossils of Southeastern Nebraska;* by F. B. MEEK.

THROUGH the politeness of Prof. Geinitz, I have received a copy of his interesting and accurately illustrated work on the Upper Paleozoic rocks and fossils of southeastern Nebraska.* The numerous excellent figures he has here given, of many of our fossils not previously illustrated, will certainly be a great assistance to students, and place them under many obligations to the distinguished author. Being very reluctantly compelled to differ widely from him, however, in regard to many of his identifications and interpretations of these fossils, and feeling it to be a duty to correct errors into which he has fallen, it is but fair to first explain the difficulties with which he had to contend in entering upon this investigation. In the first place, he was, to a great extent, unacquainted with the Coal-measure fossils of this country, and wholly unprepared to understand and appreciate the remarkable mingling here of Coal-measure and Permian types and the frequent alternation of beds containing these two types of fossils, through a considerable thickness of strata. In addition to this, he was necessarily compelled to identify, and form all his conclusions respecting, a number of species described in this country, from descriptions alone, unaccompanied by illustrations; while the collections were submitted to him with erroneous views respecting the relations of the beds from which they were obtained, to the Coal-measures of that region.

It is also proper to further explain, for the information of general readers not familiar with Natural History, that differences of opinion in regard to such matters often arise from the fact that there are two schools of observers amongst paleontologists, as well as amongst investigators in recent zoology. Those of one of these schools give a very wide latitude to genera and species, while those of the other restrict both within more precise limits. That is to say, the first often include in a single genus types which those of the other school distribute into two or more genera, or in some cases, refer even to distinct families. Upon the same principles, those of the first school often regard as mere varieties or unimportant modifications of the same species (if they notice the differences at all) forms that the others consider specifically distinct. As might be expected, these different views respecting the value and importance of distinctive characters sometimes lead to very different conclusions, not

* Carbonformation und Dyas in Nebraska, von Dr. H. B. Geinitz, M. d. k. L-c. A. d. N. Dresden, 1866.

only in regard to the geographical range of living animals, but also amongst paleontologists, in regard to the geological range, and duration in time, of extinct species and genera; and, as a consequence, respecting the ages and relations of formations. It is proper to add here, however, that the developments of modern zoology are constantly forcing upon our attention the absolute necessity for closer and closer attention to less striking differences in distinguishing genera and species, before we can hope to arrive at reliable conclusions in paleontology.

When it is understood that, out of a list of about ninety species of fossils enumerated by Prof. Geinitz from the beds in Kansas and Nebraska which he regards as belonging in part to the Carboniferous, and in part to the Permian, he identifies about fifty of these species with European, and in part East Indian forms, it will be readily understood by any one familiar with our fossils, that he must be one of those who admit very great diversities of characters as being consistent with specific identity. But before entering upon the discussion of differences of opinion respecting species, it may be well to mention some of the cases where we differ in regard to genera.

First the impropriety of referring to the genus *Turbonilla*, founded upon very small recent shells, ornamented with regular longitudinal costæ, and provided with a *sinistral apex*, shells with only revolving costæ, and a non-reversed apex, such as his *T. Swallowiana*, although not unfrequently done by other paleontologists, must be obvious to those familiar with living Mollusks. That these shells have not a sinistral apex, is well known to the writer, from careful examinations of several allied species from the Coal-measures of Illinois, in which the spire could be traced by the aid of a magnifier, to a minute point, without showing the slightest indications of a reversed apex.* To those unaccustomed to give attention to such characters, this may seem to be an insignificant distinction, but every well informed conchologist is aware that it is found to be coexistent amongst recent shells, with important differences in the anatomy of the animals inhabiting them. For the same reason, as well as on account of their generally much larger size, we may question the propriety of referring *any* of the paleozoic shells often described by paleontologists under the name *Chemnitzia*, and *Loxonema*, to the existing genus *Turbonilla*.

Again we have good reason for believing Prof. Geinitz is far from right in referring the common Coal-measure shell *Euompha-*

* One of the little shells here alluded to, was described by Dr. Stevens from the Coal-measures of Illinois under the name *Aclis minuta* (this Jour. II, xxv, p. 259); and another by Mr. Worthen and the writer from the same horizon, as *Turritella?? Stevensana* (Geol. Report Ill., ii, p. 382). It is quite improbable that they belong either to the genus *Aclis* or *Turritella*, but they are certainly not Turbonillas.

lus rugosus Hall (not Sowerby), to the articulate genus *Spirorbis*. This shell is probably not a *Euomphalus*, but seems to be more nearly allied to the *Molluscan* genus *Bifrontia*. At any rate, of the thousands of specimens that have been found weathered out of the coal shales of the west, not a single one, so far as known to the writer, has ever been seen attached by the substance of even the first whorl of the shell to any other body; nor are we aware that any scar of attachment has ever been observed on either side of the shell, although they have been frequently examined under a magnifier with the view of determining this very question, in numerous perfect examples, entirely free from the matrix, and showing clearly all the volutions on both sides to the very center.

Nor is Prof. Geinitz's reference of his little *Murchisonia subtæniata*, to that genus, or *family* even admissible. It belongs on the contrary, to the genus *Orthonema* M. & W. (Ill. Report, vol. ii, pl. 31, f. 14), a group of small shells resembling *Murchisonia* in form and revolving markings, but differing in being *entirely without the slit or sinus in the lip* characterizing that whole family of shells. Prof. Geinitz did not see a sinus in the lip of his specimen, nor the corresponding revolving band, but thought a flattened space between two little revolving ridges might be a band, though he acknowledges that this view would indicate a proportionally wide flat band. In order to settle this point, however, an excellent specimen of the species *subtæniata*, was borrowed from Dr. White, the state geologist of Iowa, obtained from exactly the same horizon in the western part of that state, and on examining this by a cross light, under a good magnifier, its lines of growth were seen passing straight across the whorls, without making the slightest flexure such as we see in *Murchisonia* and other genera provided with a sinus in the lip. Several allied species of this genus are known in the Coal-measures of Illinois.

His reference of such shells as the so-called *Modiola squamosa* and *M. acuminata* of Sowerby (as illustrated in Prof. King's Perm. Foss.), to the genus *Aucella*, is also believed to be done on questionable grounds. The genus *Aucella*, it will be remembered, was founded by Count Keyserling, upon a group of Jurassic shells, differing from those mentioned above, not only in wanting their broad cardinal area, marked with linear parallel cartilage furrows, but also in possessing a little abruptly projecting anterior ear, defined in the right valve by a deeply impressed linear furrow extending from the beak to the margin, and terminating there in a sharply cut byssal emargination. Now on examining Prof. King's excellent figures of testiferous examples of the English shells mentioned above, it will be seen that they show no traces whatever, of this little anterior ear, though his

figures of internal casts illustrate clearly the broad furrowed cardinal area of *Myalina*, to which genus these shells appear to belong.

It is true Prof. King's figures respecting *internal casts* of these shells, show a little projection between the beaks (as do some of our American species of *Myalina*), that might be mistaken for little ears,* but it is easy to see from perfect specimens showing that outside of the anterior margins of the shell, that these are not external ears, but the casts of a little cavity upon a kind of shelf or septum in the beaks, as stated by Prof. King. Prof. de Koninck mentions this little shelf and its concavity, in describing the genus *Myalina*; and although a more or less variable character, sometimes even in different individuals of the same species, evidences of its existence can generally be seen in the different species of that genus.

Prof. Geinitz has figured in his valuable work "Dyas" under the name *Aucella Hausmanni* (of which he regards the English species *squamosa* and *acuminata* synonyms), German examples of a shell that show, in one of the figures, some indications of a little anterior ear; but if it is really such, and not due to the accidental compression of the valves, as its absence in his other figures indicate, and the shell otherwise agrees with *Aucella*, we may well question its identity with the English forms mentioned above. It is also worthy of note, that Goldfuss's figures of the type of his species *Hausmanni* show no traces whatever of such ears. These shells sometimes have a slight prominence of the anterior margins of the valves, as we see in *Modiola*, but as we know by examining numerous examples of the allied American forms, there is never a defined ear, or sinus, but on the contrary, the margins of the valves fit closely there, and round up to the extremity of the hinge exactly as in *Modiola*.

Another mingling of distinct types under one generic name, is Prof. Geinitz's reference of such shells as the so-called *Monotis speluncaria*, and *Pinna prisca*, to the genus *Avicula*. The first of these types, it will be remembered, is exceedingly unlike the recent shells upon which the genus *Avicula* was founded; being nearly circular, plano-convex shells, with scarcely any perceptible obliquity, and almost destitute of proper alations at either extremity of the hinge. These and other differences led Prof. King to separate the species *speluncaria*, from the genus *Avicula*, and to place it provisionally in the genus *Monotis* Bronn, in which he has, until recently, been generally followed, both in this country and in Europe. On comparing the American

* A precisely similar cavity exists between the beaks of *Amphicælia*, Hall, from the Upper Silurian; and internal casts of these look very much like little ears, which the writer at one time supposed them to be; but good specimens of the shell preserving perfectly the anterior margins of the valves, show clearly that there is no external anterior ear whatever.

shells of this type, in 1864, with authentic European examples of the type of Bronn's genus *Monotis* (*M. speluncaria* of the St. Cassian beds), the writer was led by the very nearly equivalve character, and entire *absence of any traces of a byssal emargination* in the latter, to regard these two forms as belonging to distinct genera, and consequently to propose for the *speluncaria* group, the name *Eumicrotis*,* not being at that time, nor until very recently, aware that Beyrich had nearly two years previously proposed to separate this group from *Monotis*, on precisely the same grounds, under the name *Pseudomonotis*.† Prof. Geinitz thinks that if this type should be separated at all from *Avicula*, it should be referred to *Aucella*, which was also sometime back suggested by Prof. McCoy. Although this would be more nearly correct than to refer such shells to *Avicula* or *Monotis*, a strictly systematic classification of all the various groups of the *Aviculidæ*, would forbid such an association.

If those who hold that a natural classification requires the separation of such forms as the genera *Cassianella*, *Pseudomonotis* and *Avicula*, surely they will very decidedly protest against the reference to the latter genus of such shells as the so-called *Pinna prisca* Münster, (=*Avicula pinnæformis* Geinitz).‡ Indeed it seems scarcely possible to conceive of two bivalves within the limits of the same family, more unlike than this and *Avicula;* almost the only character by which it can be distinguished generically from those slender, straight, elongated Carboniferous species of *Pinna*, being the position of its nearly obsolete beaks a little behind the rather pointed anterior extremity, instead of being terminal. Conchologists will readily understand how unlike *Avicula* it must be, when it is mentioned that Prof. Geinitz at one time even referred it to the genus *Solen*.

* This Jour., II, xxxvii, 216.

† The note of only about one page in which Beyrich proposed the name *Pseudomonotis* for this genus (Zeitschr. der Deutsch. geol. Gesselsch, xiv, p. 10), being unaccompanied with illustrations, or a conspicuous heading to distinguish it from other matter, had escaped the attention of the writer in preparing a classification of the *Aviculidæ*, or the name *Pseudomonotis* would have been adopted. In the same note Prof. Beyrich proposed another genus *Cassianella*, with the *Avicula gryphæata* of Münster as its type. For this, the writer, on the same grounds, proposed the name *Gryphorhynchus*, in 1864. Beyrich's names for both of these genera, however, having priority of date, will have to take precedence. Although neither of these genera would be admitted by those who give such wide limits to groups, it is manifest that such distinctions are attracting the attention of systematic workers everywhere. For instance, Laube adopts *Cassianella* as a good genus in his beautiful Monograph of the St. Cassian fossils recently published. He also there proposes, on apparently good characters, a genus *Hörnessia*, for a group of which the so-called *Gervillia socialis* of authors is the type; though it is probable this will prove to be a synonym of Mr. Gabb's genus *Rhynchopteris*, published in the California Report in 1864, and founded upon a shell presenting similar external characters, and from near the same horizon, in Nevada.

‡ For this type the writer proposed the name *Aviculopinna*, in 1864, (this Jour., vol. xxxvii, cited above.

The propriety of referring the little Permian and Carboniferous shells for which Prof. King proposed the name *Bakevellia*, to the genus *Gervillea*, is, to say the least, very doubtful. Although these types are unquestionably closely related, the uniform smaller size of the species of the former group, the more nearly equal convexity of their valves, usually smaller number of cartilage cavities, and generally less elongated form in proportion to the length of the hinge line, are characters which, when viewed collectively, indicate generic differences. The most important distinction, however, is found in the hinge teeth, which although variable in both groups, differ in that those on the posterior side of *Bakevellia* are elongate, linear and directed parallel to the hinge line, instead of being shorter and oblique; while those in front of the beaks range obliquely forward and downward, instead of forward and upward, as in *Gervillea*. Again *Bakevellia* has the anterior muscular scar proportionally larger, so much so indeed that Prof. King referred the genus to the *Dimyaria*, though it belongs to the *Avicula* group near *Gervillia*.

Again, in including in the genus *Pecten* the Paleozoic shells for which Prof. McCoy proposed the name *Aviculopecten*, Prof. Geinitz ignores important distinctions that have been known for fifteen or sixteen years past, to clearly separate these groups. These are the proportionally larger size of the posterior ear in *Aviculopecten*, instead of the reverse, and its broad *Pterinea*-like cardinal area, or hinge plate, with parallel longitudinal cartilage furrows, and in general without traces of a central cartilage pit under the beaks. Even Woodward, who was the most extremely conservative of all modern conchologists, in regard to generic distinctions, not only separated these shells from the genus *Pecten*, but even placed them doubtfully in the family *Aviculidæ*. No well informed conchologist would at the present time refer to the genus *Pecten*, as properly restricted, any Paleozoic species.*

He is also behind the present state of conchological science in placing in the genus *Arca* forms like the so-called *A. striata* Schlot. (sp.), with the posterior hinge teeth linear, elongated and ranging parallel to the cardinal margin. These belong to the genus *Macrodon* of Morris and Lycett. Even Woodward separates this group from *Arca*, but without sufficient reason includes it as a subgenus under *Cucullæa*. There are no true Arcas in the Paleozoic rocks.

Another unnatural mingling of distinct types is his reference of typical Ledas (properly *Nuculana*,) to the genus *Nucula*.

* Prof. Agassiz, who has gone over the whole family *Pectenidæ* with great care, and his usual thoroughness, does not, if correctly understood by the writer, refer *any* of the fossil species from older rocks than the Tertiary, to the genus *Pecten*, as properly restricted.

Woodward, Carpenter, Gray, H. & A. Adams, Deshayes, Chenu, in short, all good conchologists admit this as a distinct *genus* from *Nucula;* while Carpenter, H. & A. Adams, Mörch, and other late systematic writers, separate it as the type of a distinct *family* from the *Nuculidæ.*

But the most unaccountable error into which Prof. Geinitz has fallen, is in placing in the genus *Rhynchonella*, *Spirifer hemiplicatus* of Hall, the type of the new genus *Syntrilasma*, Meek & Worthen (Ill. Geol. Report, ii, 321). Being a somewhat peculiar shell, if the cardinal region of the valves was hidden in the matrix, and the surface striæ somewhat obscured, it might be mistaken for a *Rhynchonella;* but the most surprising thing is that he should have referred it to that genus, when the very specimens figured by him show it to have a straight hinge line, and a well defined cardinal area,* divided in the ventral valve by a triangular open fissure, while another figure shows it to have in the dorsal valve, the crura and *cardinal process*, as in *Orthis.* The fact is, this shell does not even belong to the *Rhynchonellidæ*, as its punctate structure and other characters show. The fact that Prof. Geinitz, after referring it to *Rhynchonella*, speaks of it as "this rare and beautiful *Terebratula*," would also seem to indicate that he does not even regard the distinctions between these two genera (well known to be the types of two distinct families), of much consequence.

Again Prof. Geinitz overlooks important distinguishing characters, when he refers (without even a recognition as a subgenus) to the genus *Orthis*, a typical *Streptorhynchus* (properly *Hemipronites*). The distinctions between these types are well defined, so much so that even Mr. Davidson, who is always cautious and conservative in admitting even subgenera, considers it a good subgenus; while most of the highest authorities in various departments of recent zoology view differences of no greater importance as being of full generic value.

Any of the numerous collectors of western Coal-measure fossils will at once recognize the spines figured by Prof. Geinitz (pl. iv, fig. 29), and referred by him to *Actinocrinus*, as those of *Zeacrinus mucrospinus* McChesney. These spines, probably belonging to two or more allied species, are widely distributed in our Coal-measures, from West Virginia and Pennsylvania, to

* It is scarcely necessary to explain here that when Prof. de Koninck speaks of an area, in describing *Rhynchonella angulata* Linn (to which species Prof. Geinitz refers the shell under consideration), he alludes to a flattened oval space on each side of the shell, converging to the beaks at an angle of about ninety degrees, and not to a true cardinal area, such as that term is applied to in describing Brachiopods generally. If any one, however, has any doubts on this point, these will at once be removed by turning to Mr. Davidson's excellent figures and description of *R. angulata* (Monogr. Brit. Carb. Brach., p. xix), prepared after a careful study of Linnæus's original specimen.

Nebraska, and southward to Texas and New Mexico; while they may be at a glance distinguished from those of any of the forms usually referred to *Actinocrinus*. They belong indeed to different parts of the crinoid, being modified second radial pieces, while those of *A. cornigerous*, and *A. Gouldi*, with which Prof. Geinitz compares them, are modified vault-pieces, that rise obliquely upward out of the vault from above the horizon of the arms. This difference in the position and relations to the other parts, of these spines, imparts an entirely different form to the head or larger extremity, from those of any of the Sub-carboniferous crinoids, that renders it very easy to distinguish them. It is unnecessary to inform any one acquainted with western fossils, that no species of *Actinocrinus*, even giving that genus its widest limits, has yet been found above the horizon of the St. Louis Limestone, of the Sub-carboniferous series, and the only two species found thus far up belong to the *Batocrinus* section.

Having thus pointed out what are believed to be errors in regard to generic references, respecting which students who may use Prof. Geinitz's work ought to be informed, some remarks on the specific relations of these fossils may not be out of place.

First a little planorbicular shell (fig. 6, pl. 1), referred by Prof. Geinitz to *Serpula* (*Spirorbis*) *planorbites* Münster, is certainly, as he suspected, the same figured and described by Prof. Hall from the Coal-measures of Illinois under the name *Euomphalus rugosus*, in the Iowa Report. The reasons, however, for not believing it to belong even to the same primary division of the Animal Kingdom as the genus *Spirorbis*, have already been stated. That it is also clearly distinct specifically from the European *S. planorbites*, even if they could be forced into the same genus, is more positively certain, as I know from a direct comparison with authentic foreign specimens of the latter.* Of the Nebraska shell I have numerous specimens before me, from various localities in that region, as well as from Kansas, western Iowa and from Illinois. On comparing these with German examples of *S. spirorbites*, they are easily distinguished by having the whorls always *very distinctly* quadrangular, and broadly flattened on the outer side, instead of presenting an oval section with a rounded or subangular dorsal side as in the German species. The latter also has its deepest umbilical concavity on the left side (placing the shell with the mouth turned downward and away from the observer), instead of the reverse. Prof. Geinitz had also observed that there is a shallow furrow around the middle of the side of the whorls in the Nebraska fossil, where there ought to be a prominence to make it correspond to the *S. spirorbites*, but thinks this is due to the accidental pressing inward of this prom-

* All the foreign specimens of Permian fossils alluded to in the paper belong to the Museum of the Smithsonian Institution.

inence. This obscure furrow, however, is a natural character in the *E. rugosus*, though not always equally well defined, and sometimes becoming obsolete. Finally it attains a size of from four to six times that of the *spirorbites*. The latter, as shown by Prof. Geinitz's figures in his "Dyas," as well as by the specimens, varies considerably in some respects, but the American shell is *very* constant and regular in form, and in most of its characters.

I differ, if possible, still more decidedly from Prof. Geinitz, in thinking *Spirorbis helix* of King identical with this; and doubt the identity of King's species with the true *S. spirorbites*. If our shell is identical with any European species, it agrees most nearly with the Carboniferous species *Euomphalus carbonarius* Sowerby (= *E. quadratus* McCoy, Carb. Foss. Ireland, pl. 5, fig. 22), which it quite nearly resembles, though even these forms are clearly distinct.

Murchisonia subtæniata Geinitz, Carb. und Dyas, pl. 1, fig. 18. As already stated this is a true *Orthonema*, and will have to take the name *O. subtæniata*.

Bellerophon interlineatus Portlock. Geinitz, ib. This may or may not be identical with Portlock's species. At any rate it occurs in the Coal-measures of Kansas. The *B. carbonarius*, and *B. Montfortianus* N. & P. mentioned by Prof. Geinitz among other fossils from the beds he refers to the Dyas, are well-known Coal-measure species in the West. His *B. Marcouanus* seems to be a good new species.

Macrocheilus Hallianus Geinitz, ib., fig. 7. This probably belongs to the genus *Soleniscus* Meek & Worthen (Illinois Report, ii, pl. 31, fig. 15), as it presents much the appearance of specimens of the type of that genus with the beak and lower part of the outer lip broken away. If the specimen figured has had an *accidental* depression made on the columella above the fold, it may even be the typical species originally described from the Coal-measures of Illinois.

Allorisma elegans King. Geinitz, ib., f. 21. If we may judge from the published figures and descriptions of this species, there can be little room for doubting that the Nebraska shell figured under that name is a distinct species, even after making liberal allowances for variations. If so, it may be called *Allorisma? Geinitzi*, though it seems very doubtful whether it is a true *Allorisma*. It appears to be congeneric with, and allied specifically to, species described by Dr. Shumard from the Coal-measures of Kansas and Missouri, under the names *Leptodomus Topekaensis*, and *L. granosus*. It is probable that all these shells should be referred to the genus *Sedgwickia* of McCoy, as properly restricted to the types for which that name was first proposed (see Paleont. Upp. Missouri, p. 38).

Solenomya biarmica de Vern. Geinitz, ib. The specimen figured

is too imperfect for satisfactory identification or to show any reliable characters for distinguishing it from forms in our Coal-measures.

Astarte gibbosa McCoy. Geinitz, ib., fig. 23. This agrees quite nearly with McCoy's figure, but to establish *positive* specific identity would require a comparison of specimens showing the hinge and interior, which *might* even show them to belong to different genera. They are probably both Edmondias, however, and look unlike *Astarte*. Dr. White finds them in the Upper Coal-measures of Iowa.

Astarte Nebrascensis (n. sp.), and *A. Mortonensis* Geinitz, ib., as well as the form he figures *A. Vallisnerianus* King, have more the aspect of *Astarte;* but the latter looks less like Prof. King's figures than the form figured as a new species *A. Nebrascensis*. At any rate, specific identifications, and even generic references of such shells, can be admitted only provisionally, until the hinge and interior is known.

Schizodus obscurus Sowerby, and *S. Rossicus* de Vern. The forms figured under these names on plate I, resemble these European shells quite nearly; but it must be obvious that in a genus like this, in which species vary more or less in outline, and present so few characters for identification, little reliance can be placed upon identifications from external characters only, especially when the specimens were obtained at so widely distant localities. The form referred to *S. obscurus* (figs. 30 and 31), looks more like Prof. King's figures of *S. Schlotheimi* Geinitz, as well as more like natural casts of that species now before me from Germany, than like Sowerby's or King's figures of *S. obscurus*, which shows more elevated, and more ventricose beaks. From a tracing of the type of Prof. Swallow's *Cypricardia? Wheeleri*, described from the Missouri Coal-measures, it appears almost certain that it is the same here figured under the name of *S. obscurus*. Young examples of *S. alpina* (=*Dolabra? alpina* Hall, Iowa Rep., pl. 29, f. 2) from the Lower Coal-measures, in some of its variations, rather nearly resemble the form referred by Prof. Geinitz to *R. Rossicus*, though that is doubtless a distinct species. Dr. White finds both of the shells figured by Prof. Geinitz near the middle of the Upper Coal-measures of Iowa.

Arca striata Schlot. Geinitz, ib., fig. 32. As already explained, the shell figured by Prof. Geinitz under this name is a true *Macrodon*. It is the same species described by Mr. Worthen and the writer (Proceed. Chicago Acad. Sci., i, p. 17) from the Coal-measures at Springfield, Illinois, under the name *M. tenuistriata*. It differs clearly from the European *M. striata*, however, of which I have good examples at hand for comparison, in having its radiating lines very much smaller, or reduced to minute obsolescent striæ on the middle and anterior half of the valves. The speci-

men figured by Prof. Geinitz only retains the shell at the posterior end, where the striæ are stronger, and agree more nearly with those of the European form. Through the politeness of Dr. White, I have had an opportunity to compare good gutta-percha casts of the hinge of this shell, from the same horizon in western Iowa as the Nebraska City beds, and they agree well with the Illinois shell. I am aware that *M. striata* varies in the size of its striæ, but it never has them reduced to very minute or obsolete lines on the anterior part of the valves, like the American species, which is quite constant in this character. I agree with Prof. King and others in believing some of the European forms Prof. Geinitz thinks identical with the species *striata*, are specifically distinct.

Nucula Kazanensis de Vern. Geinitz, ib., f. 33–34. The figures of the species *Kazanensis*, originally published in the Geology of Russia, being merely from imperfect moulds left in the matrix, do not afford a reliable means for comparison, though they look like the Nebraska shell. Whatever may be its relations, however, to the *Kazanensis*, it will be readily recognized by those familiar with the western Coal-measure fossils, as the form described by Dr. Stevens from the Coal-measures of Illinois under the name *Leda bellistriata*. Of course it is not a *Nucula*.

Nucula Beyrichi Schloth. Geinitz, ib., 36 and 37. This has the form of a true *Nucula*, and agrees pretty well in form with Prof. Geinitz's figures of German examples of that species given in Prof. Geinitz's "Dyas," but less nearly with specimens sent from Germany under that name. They are probably the same described by McChesney from the Coal-measures under the name *N. parva*.

Clidophorus Pallasi M. V. & K.* Geinitz, ib., pl. II, fig. 3, (fig. 4 appears to represent some other shell.) This figure was evidently made from the internal cast of a shell very near, if not identical with, *Pleurophorus occidentalis* Meek & Hayden, to which *genus* at least it certainly belongs. It may, or may not be, identical with some of the German shells referred to the Russian species *Pallasi;* but if we are to be guided in regard to the true characters of the type of that species by the figures and description published by its founders in the Geology of Russia, the Nebraska shell, which is shown to have the posterior hinge-teeth at least of *Pleurophorus*, must be a very different type, since the Russian species is both figured and described as being "*completely edentulous.*" The Russian species is therefore not a *Pleurophorus* (= *Clidophorus*) at all, but is more probably, as suggested

* If *Pleurophorus* and *Clidophorus* are synonyms, or only sections of the same genus, it is *Pleurophorus* and not *Clidophorus*, as Prof. Geinitz seems to think, that must take precedence, as King proposed the former genus, naming the so-called *Arca costata*, as its type, in 1844, while *Clidophorus* was not published by Prof. Hall until 1847.

by Prof. King, a *Cardiomorpha*. It also differs from the Nebraska shell in having the internal ridge bounding the anterior muscular scar (as shown in the figures and mentioned in the description) ranging obliquely backward and downward at an angle of 45° to the axis of the valves, instead of nearly at right angles to the same, as shown in the figure of the Nebraska species.

I have now before me an internal cast, and a specimen showing the exterior, of what are strongly suspected to be two very distinct types, that came from Germany with the name *Clidophorus Pallasi* attached. The one showing the exterior agrees quite well with some of Prof. King's figures of his *Cardiomorpha modioliformis*, which Prof. Geinitz cites as a synonym of the Russian species *Pallasi;* but the other specimen, that is, the internal cast, shows that *it*, at least, is a true *Pleurophorus*, as it has a hinge with teeth like the Nebraska shell; while one of Prof. King's figures of a cast and his description show that his *modioliformis* is edentulous, like the species *Pallasi*.

From these facts, it seems highly probable that two types are, at any rate sometimes, confounded in Germany, under the name *C. Pallasi*;* that is, one edentulous, agreeing perhaps specifically with Prof. King's *modioliformis*, and another with a toothed hinge, or in other words a true *Pleurophorus*. If the Nebraska shell belongs to any European species, it is far more probable that it is identical with *Pleurophorus costatus*, with casts of which, now before me from Europe, Prof. Geinitz's figure closely agrees.

Clidophorus (*Pleurophorus*) *occidentalis* M. & H. Geinitz, ib., tab. ii, fig. 6. The shell figured under this name is certainly not the *P. occidentalis* Meek & Hayden. In that species, the beaks are, as described, narrow and projecting beyond the termination of the hinge, being in fact nearly or quite terminal, while its dorsal outline is straight or even a little concave from the beaks posteriorly. The form figured by Prof. Geinitz is, so far as known to the writer, new, and may be called *Pleurophorus subellipticus*.

Cl. (*Pleurophorus*) *simplus* von Keyserling. Geinitz, ib., fig. 5. Prof. Geinitz did not have specimens of this shell from Nebraska, but gives a figure copied from Dana's Geology of a specimen from the Permian rocks of Kansas. It is the *P. subcuneatus* M. & H., and occurs both in the Permian and Permo-carboniferous beds. It varies considerably in form, and some of the varieties like that figured in Prof. Dana's Geology resemble *P. simplus*, though among all of the hundreds of examples I have seen, not one is proportionally so slender and elongated as the figure of the Russian shell. Nor have any of them the posterior hinge-teeth prolonged nearly so far backward.

Clidophorus solenoides Geinitz, ib., fig. 7. This is a good species of genus ?

* Prof. King says Prof. Geinitz formerly confounded *Pleurophorus costatus* with the edentulous so-called *Mytilus Pallasi*.

Aucella Hausmanni Goldf. Geinitz, ib., fig. 8. This is doubtless a *Myalina* resembling the *M. squamosa* of England, but it is less nearly like *M. Hausmanni*, as figured by Goldfuss, and quite unlike Prof. Geinitz's figures of German specimens referred to that species. It is doubtless the same as *Myalina Swallovi* of McChesney, from the Missouri Coal-measures. I have also seen a similar form from beds in Nova Scotia, referred by good authorities to the Sub-carboniferous.

Mytilus concavus? Swallow. Geinitz, ib., fig. 9. This is not the form described by Prof. Swallow, which has angular instead of rounded umbonal slopes. It may be a *Myalina* but it is *certainly* not a true *Mytilus*.

Myalina perattenuata M. & H. Geinitz, ib., fig. 10–11. Correctly identified, but it is specifically distinct from *M. permiana* Swallow (cited by Geinitz as synonym), which has less attenuated beaks.

Myalina subquadrata Shumard. Geinitz, ib., figs. 25 and 26. Correctly identified. It is common in the upper Coal-measures of this region, and has been found by Dr. White in the same horizon in Iowa.

Avicula speluncaria Schlot. Geinitz, ib., fig. 12. As already stated, this belongs to Beyrich's genus *Pseudomonotis*. The specimen figured by Prof. Geinitz is not from Nebraska, but was sent to him by Prof. Dana from the Permian beds of Kansas, and is the same shell described by Dr. Hayden and the writer under the name *Monotis Hawni*.* It nearly resembles the European species *speluncaria*, and may *possibly* be identical, but good European specimens of that species now before me can be distinguished from the American form. At any rate we have a specimen from a bed of nearly black limestone, far down in the Coal-measures at Leavenworth, Kansas, agreeing even more nearly with *P. speluncaria* than *P. Hawni* does. Similar forms occur at different horizons in the Coal-measures and Permo-carboniferous beds in Kansas, and have been found in the Upper Coal-measures of Iowa, by Dr. White.

Avicula pinnæformis Geinitz, ib., fig. 13. From specimens of this shell shown to me by Dr. White from the same horizon in Iowa, I am sure it is specifically distinct from the so-called *A. pinnæformis*, and there can be little doubt that it even belongs to the distinct genus *Pinna*.

Gervillia parva M. & H. Geinitz, ib., 14. This differs from the *Bakevellia parva* M. & H. in having a broad shallow depression extending to the anterior basal margin from the umbonal region, farther back than that defining the anterior ear from the

* The species *Hawni*, will have to take the name *Pseudomonotis Hawni*, and the Illinois shell, supposed to be a variety of the same but probably distinct, may be called *P. sinuata*. (See Ill. Geol. Report, ii, pl. 27, fig. 12–13.)

swell of the umbo in *B. parva.* It is an interesting fact, however, that there is a little shell, of which we have specimens for comparison, in the Nova Scotia beds, referred by the highest authorities to the Sub-carboniferous, agreeing with it in this character as well as apparently exactly in all other respects.

Gervillia longa Geinitz, ib., ii, fig. 15. A good species, but its position in the genus *Gervillia* is very doubtful. It occurs in Iowa, in a bed referred by Dr. White to the upper part of the Lower Coal-measures, with other fossils of that horizon.

G. (*Avicula*) *sulcata* Geinitz, ib., fig. 16. Also a good species.

Pecten neglectus Geinitz, ib., fig. 17. Appears to be a good species, but should be called *Aviculopecten neglectus.*

Pecten Missouriensis? Shumard. Geinitz, ib., fig. 18. This is certainly not the *Aviculopecten Missouriensis* of Shumard, which is not known from any horizon above the St. Louis limestone of the Sub-carboniferous series. It is the shell called *P. occidentalis* by Dr. Shumard, and afterward named *P. Cleavelandicus* by Prof. Swallow. It is one of the most widely distributed of our Coal-measure shells throughout the West, and ranges up through the Permo-carboniferous beds into the Permian of Kansas. No form nearly allied to it has ever been found in the western Sub-carboniferous rocks, but specimens now before me from rocks in Nova Scotia, so referred by the most reliable authorities, seem to be undistinguishable from it.

Pecten Hawni Geinitz, ib., fig. 19. This seems to be quite similar to *Pecten Broadheadii* of Swallow, described from the Missouri Coal-measures. If distinct from that species it should be called *Aviculopecten Hawni,* unless it may possess internal characters showing it to be the type of an undescribed genus. Dr. White finds it in the upper beds of the Lower Coal-measures of central Iowa.

Rhynchonella angulata Linn. Geinitz, ib., tab. iii, fig. 1–4. As it has already been shown that the shell figured under this name is not a *Rhynchonella* at all, little need be said in regard to its *specific* relations to the European true *Rhynchonella angulata.* I hope, however, that I shall be excused for adding here, that the practice of positively identifying species from widely distant parts of the earth upon such merely superficial points of general resemblance, and thus complicating and vitiating all conclusions respecting the geographical and geological range of species, cannot be too carefully avoided.

Camarophoria globulina Phillips. Geinitz, ib., fig. 5. Of this shell I have numerous examples from the same position, as well as from other horizons of the Upper Coal-measures of Missouri, Kansas, Nebraska and Iowa. It has generally been referred to *Rhynchonella Uta* of Marcou, who has himself identified it with that species. On comparison with authentic European examples

of *Camarophoria globulina* of Phillips, it is found to be very similar in external characters, but there is an insurmountable difficulty in the way of referring it to that species,—that is, because sections across the beaks, as well as internal casts, show it to be *a true Rhynchonella*?

Retzia Mormonii Marcou (sp.). Geinitz., ib., fig. 6. This is the species described by Dr. Shumard from the Coal-measures as *R. punctulifera*, and his name probably has priority. It is a very common Coal-measure and Permo-carboniferous form in the west. Prof. Marcou mentions finding it at Nebraska City associated in bed C of his section with the other species referred by him and Prof. Geinitz to the Dyas;* though Prof. Geinitz does not mention it among the Dyas fossils at all, but refers it to the Carboniferous, giving Plattsmouth as the locality. Prof. Geinitz makes the California *R. compressa* a synonym of this, but the reasons for doing so are not very apparent, the two shells being quite different; he might with more propriety make the *R. Mormonii* a synonym of the European species *R. radialis* Phillips.

Athyris subtilita Hall, a form generally referred to *A. planosulcata* Phillips, *Spirifer planoconvexus* Shumard, *S. cameratus* Morton, and *Streptorhynchus crenistria* (properly *Hemipronites crenistria*), the so-called *Orthisina Missouriana*, figured or mentioned by Prof. Geinitz from beds he refers in part to the Dyas, and in part to the Carboniferous, all occur together, with the *Rhynchonella Uta*, *Retzia Mormonii*, and all of the *Producti* mentioned by him, as well as *Fusulina cylindrica*, in the same or alternating beds of the Coal-measures and Permo-carboniferous beds in Kansas, while *Athyris subtilita* ranges up into the highest beds containing Permian types.

Prof. Geinitz makes Mr. Davidson's East Indian *Spirifer Moosakhaliensis* a synonym of *S. cameratus* Morton. In this, however, he is certainly mistaken. Out of all the thousands of specimens of *S. cameratus* found in our western Coal-measure and Permo-carboniferous rocks, not one shows the distinct regular concentric lamellæ seen on that species, while there are other differences not to be overlooked.

Spirifer laminosus McCoy. Geinitz, ib., fig. 19. This is *positively* not *S. laminosus* McCoy, but merely a variety of *Spiriferina Kentucensis*, of Shumard. It agrees with *S. laminosus* in no specific character excepting the possession of regular laminæ of growth, *S. laminosus* having a high flat area like a *Cyrtia* (to which group Prof. McCoy referred it), and a broad rounded mesial fold and sinus without longitudinal plications. One of McCoy's figures of a distorted specimen seems to show a plication in the sinus, but it is only necessary to consult Mr. Davidson's excel-

* See Bull. Soc. Geol. France, t. xxi, p. 137, 1864.

lent figures and description of this species in his Monograph of the British Carboniferous Brachiopoda, or Prof. McCoy's description in his British Paleozoic fossils, to be convinced that the two shells are totally distinct. Indeed they probably belong to distinct subgenera or genera, as the *S. Kentuckensis* seems to be punctate like *Spiriferina.*

He is probably right in making Prof. Swallow's so-called *Orthisina Missouriana* a synonym of *Plicatula striato-costata* Cox, which I had done some years since. Dr. White and Mr. St.John, however, have ascertained that it posesses some very extraordinary intermal characters, showing it to be typical of a new genus. Although this shell closely resembles Mr. Davidson's East Indian *Streptorhynchus pectinifera,* with which Prof. Geinitz thinks it identical, they must be specifically distinct, if Mr. Davidson's figure represents the striæ correctly as running parallel to the plications to the front margin, instead of converging toward the top of the plications near the front.

If Prof. Geinitz is correct in identifying the shell he refers, without figure or description, to *Productus horrescens* with *P. Rogersii,* it is the same described by Dr. Owen under the name *P. Nebrascensis.* Dr. Owen's figure gives a very incorrect idea of this shell, and would never be recognized as even representing an allied form, but the locality from which he obtained his specimens and his comparisons with *P. Humboldtii* d'Orbigny, led to the belief that his type was the same as the *Rogersii.* In order to settle this question I borrowed Dr. Owen's typical specimens, labelled by himself, from his brother, Prof. Richard Owen, and found it to be the common Coal-measure shell generally known in the west as *P. Rogersii.* Out of thousands of specimens of this species, showing the hinge and interior of both valves, examined under all conditions and of all ages, not one has ever been seen showing any traces whatever of the cardinal area and hinge-teeth of *Strophalosia.* In short it is a true *Productus* closely allied to *P. scabriculus.*

Productus cora, P. semireticulatus, P. costatus, P. punctatus, &c., mentioned but not figured by Prof. Geinitz, are doubtless the same Coal-measure forms usually so referred in the west, and ranging in part up into the Permo-carboniferous. That he figures under the name *P. Flemingii,* is the same Coal-measure and Permo-carboniferous shell described by Dr. Norwood as *P. Prattenianus* (as indicated by Prof. Geinitz), which is also closely allied to *P. æquicostatus* Shumard, though it is certainly not the *P. Calhounianus* Swallow, nor *P. Flemingii,* as Prof. G. thinks. The other shell he figures under the name *P. Koninckianus* de Verneuil, looks exceedingly unlike the figures of the type of that species, being more probably only a larger individual of the same he figures as *P. Flemingii.*

Productus Cancrini de Vern. Geinitz, ib., iv, fig. 6. Whatever relations the shell here figured bears to German specimens identified with *P. Cancrini*, it certainly differs from the original Russian type of that species, both in its proportions and in the prominence of its beak. At any rate I know it to range far down in the Coal-measure rocks of Kansas, below the horizon of the beds referred by Marcou and Prof. Geinitz to the Mountain limestone.

Productus Orbignianus de Koninck. Geinitz, ib., figs. 8 to 11. Prof. Geinitz seems to be right in regarding this form as the same as *P. splendens* and *P. Wabashensis* N. & P. But Mr. Davidson, however, who ought to know, refers both of these, from specimens sent him from the typical localities, to the Carboniferous species *P. longispinus* Sowerby. The shell figured by Prof. Geinitz is widely distributed and very abundant in our Coal-measures, and in Kansas ranges up into the Permo-carboniferous.

Productus horridus Sow. Geinitz, ib., fig. 7. There is no room whatever, to doubt but this is a young individual of the last mentioned species. That shell varies much in the distinctness of its costæ, which are sometimes almost entirely obsolete on even adult shells, and in young examples like this they are often not indicated at all, as may be seen by examining the the umbo of mature specimens. If *P. horridus* was known to occur in these rocks, it might be thought *possible* that this might be its young, but under existing circumstances, (that species being unknown in America), it would certainly require a considerable stretch of imagination, to see in this little shell a species which at maturity attains nearly one hundred times its size.*

Chonetes mucronata M. & W. Geinitz, ib., tab. iv, figs. 12, 14. This is correctly identified; and his *C. glabra* (ib., figs. 15 to 18) seems to be a good species. Both of these species, however, range far below this horizon in Kansas and Nebraska, even below the horizon of the beds referred by Professors Marcou and Geinitz to the Subcarboniferous.

Cyathocrinus ramosus Schlot. Geinitz, ib., fig. 19. Is from a European specimen, and given for comparison with the next, to which, however, it has no near relations. *C. ramosus* has not yet been found in any of our rocks.

Cyathocrinus inflexus Geinitz, ib., fig. 20. This species was long since described by Dr. Shumard from the Coal-measures of Missouri, under the name *Poteriocrinus hemisphericus* (Acad. Sci. St. Louis, i, p. 221). It is widely distributed in the western Coal-measures. Several specimens of it are in the Illinois collection from different localities in that state; and it is now known

* Since this was written, I have had an opportunity to examine extensive collections obtained by the Nebraska geological survey in charge of Dr. Hayden, at Nebraska City and all the surrounding country, and can assert *positively* that the little shell here figured is the young of that referred by Prof. Geinitz to *P. Orbignianus*.

to occur at Omaha, in the beds referred by Prof. Marcou to the Mountain limestone. The separate crinoid plate (fig. 27) given by Prof. Geinitz on the same plate, is a first radial piece of the same species as the above, or of *Erisocrinus*, it being impossible to distinguish this part of these *Crinoids* when found detached. The fig. 28 of same plate, evidently represents the subradial piece of the *C. hemisphericus* from the anal side, being truncated above for the reception of the first anal piece and strongly incurved below. The columns figured on this plate as *Actinocrinus*? probably belong to the same crinoid, or to *Zeacrinus mucrospinus* McChesney, the spines of which are figured there erroneously as those of an *Actinocrinus*. As already stated, no *Actinocrinus* has yet been found in this country above the St. Louis Limestone.

Eocidaris Hallianus Geinitz, ib., tab. v, fig. 1, is probably a good species, and correctly referred. The corals figured on the same plate and referred to *Cyathaxonia*, are very like Coal-measure species of the West. One of them may be the same described by McChesney from the Coal-measures of Illinois under the name *C. prolifera*. The *Fusulina* figured on the same plate as *F. cylindrica* and *F. depressa*, range through our whole Coal-measures, of Iowa, Missouri, Kansas and Nebraska, and far up into the Permo-carboniferous of Kansas.*

As the so-called *Fenestella elegantissima* Eich., *F. plebeja* McCoy, *F. virgosa* Eich., and *Polypora papillata* McCoy, figured on plate v, are all identified from fragments showing but the nonporiferous side, such identifications are of course not to be relied upon in determining the age of rocks.

Polypora marginata McCoy. Geinitz, ib., fig. 11. The poriferous surface of this looks very unlike McCoy's species.

Polypora biarmica von Keyserling. Geinitz, ib., fig. 13. If the figures of this, and the form described by Count Keyserling are even nearly correct, they are clearly distinct.

Synocladia virgulacea Phillips. Geinitz, ib., 14. Prof. Geinitz has correctly identified this with the type for which Prof. Swallow proposed the name *S. biserialis*. It differs, however, clearly from the *S. virgulacea*, in having a row of little short spines (not mere granules) along the middle of each longitudinal branch, between the two rows of pores, and *particularly* in having *but two* rows of pores, instead of from three to five. Prof. Geinitz's figure shows the nonporiferous side, but his artist (who deserves great credit for his accuracy) has well represented the impressions of the row of little spines along the middle of the poriferous side, in impressions left in the matrix.

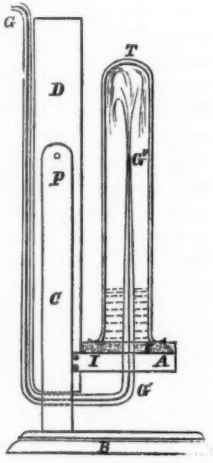
(To be continued.)

* Since this was written, I have this fossil in abundance, and many of our other common Coal-measure forms, from Nebraska City, obtained *above* the horizon of the very beds from which the so-called Dyassic fossils were obtained.

ART. XVII.—*Description of an apparatus for collecting and washing precipitates in test tubes;* by M. MCDONALD, Prof. Chem. Va. Military Institute.

THE apparatus is shown in the figure in side elevation. A is a bracket of hard wood or other suitable material, and serves as a support to the test tubes. It is firmly attached to the upright D which carries the inverted syphon tube G, G′, G″. It has a shoulder at I which abuts against the fixed support C and prevents oscillation.

Upon the bracket A rests the disk E of porous biscuit ware, and upon this, several thicknesses of filtering paper. The test tube T is adjusted as shown in the figure, and held firmly in place by a clamp (which is not shown). There is an orifice through the center of A and E through which passes the shorter branch of the inverted syphon tube G, G′, G″. This is drawn to a capillary bore at G″, and serves to introduce distilled water into the interior of the test tube for the purpose of washing the precipitate. The apparatus is supported upon the stand BC, and has a motion of rotation around the axis P.



The disks of filtering paper have a diameter slightly less than the diameter of the disk E; their centers are perforated with holes a little less in diameter than the syphon tube at the point F.

To use the instrument, several thicknesses of filtering paper are slipped over G″ and pressed evenly down upon E. The apparatus is then inverted in its frame, the test tube containing the precipitate adjusted and secured in position by the clamps and then restored to the position shown in the figure.

The syphon tube is then connected with the delivery tube of a wash bottle and a jet of distilled water thrown into the interior of the test tube.

Usually this jet may be projected against the bottom of the tube with sufficient force to wash all the precipitate down upon the filter. The test tube should fit very closely upon the support, or the pressure will force liquid and precipitate through together.

Modifications of the apparatus for special purposes will readily suggest themselves, and any one of ordinary ingenuity may construct one for himself.

ART. XVIII.—*On certain Lecture Experiments, and on a new form of Eudiometer;* by JOSIAH P. COOKE, Jr.

THE laws of combination by volume fill such an important place in our modern chemical philosophy that simple methods of illustrating these fundamental principles in the lecture room are eagerly sought by every teacher of the science. The many new and interesting experiments devised for this purpose by Prof. Hofmann, first described in the Journal of the Chemical Society of London (Ser. II, vol. iii, page 156), and subsequently made still more widely known through his admirable "Introduction to Modern Chemistry," leave little to be desired so far as regards accuracy of results or elegance of illustration. But these experiments require for the most part a delicacy of manipulation, which is incompatible with the hurry of the lecture room, and a skill in glass-blowing which can rarely be attained or commanded by our American teachers. Hence while seeking the same end as Professor Hofmann, but with less ample appliances, the author has devised for his own lecture-room methods of illustrating the same principles, which require less delicate apparatus and less careful attention, although as analytical methods they may not always be as accurate as those of this eminent German chemist. Following also the recommendation of Prof. Hofmann in the article just referred to, the author publishes his methods with the hope that they may serve to bring the illustrations of these fundamental laws of chemistry within the reach of the great body of teachers in this country.

Many of the methods described in this paper are alone rendered possible by the application of vulcanized rubber stoppers in the construction of the required apparatus. Hitherto these have not been made of good quality in this country, and those imported from Europe were very costly, and could only be obtained of a few invariable sizes. At the suggestion of the author, the "Boston Belting Co." now manufacture an excellent article, which they call "stopper cord," consisting of conical rolls of very elastic rubber, about 4 feet in length and varying in diameter from one-half an inch at one end, to an inch and a half at the other.* From these rolls, stoppers of any required size between the limits named may be cut with an ordinary knife and bored with a common brass cork-borer. It is only necessary to moisten the tools with water in order to prevent the adhesion of the rubber. Stoppers of this material are absolutely air-tight

* After a good deal of experience, rolls of the sizes named above have been found to be the most universally applicable, but they can be made to order of any desired dimension and at a cost not exceeding one dollar a pound. See fig. 5, where one of these rolls is shown in the fore-ground of the wood cut.

even against a full atmospheric pressure, provided that the surface of adhesion to the glass neck is at least half an inch in length.

Another material of prime importance in these experiments is sodium amalgam, which is most conveniently used when containing so large an amount of sodium as to form a hard solid. It is best prepared by gently heating a few ounces of metallic mercury in a shallow iron dish and then cautiously adding one-twentieth of its weight of sodium. The first half of the sodium should be added in very small portions at a time as the action at the beginning is exceedingly violent, but soon moderates, and at last the melted amalgam must be stirred with an iron spatula in order to incorporate thoroughly the materials. As soon as cold the solid amalgam readily separates from the dish, and should then at once be broken up into small fragments and preserved in a well stoppered bottle.

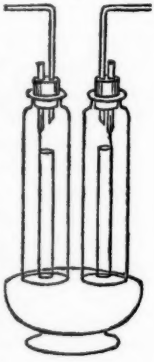
The four great typical compounds of modern chemistry are HCl, H_2O, H_3N and H_4C. Excepting the last, for which we have no new methods, we will now describe our methods of illustrating the composition of each of these in turn.

Hydrochloric acid.—The points to be illustrated in the case of this gas are all indicated by the equation $\boxed{H}+\boxed{Cl}=\boxed{HCl}$ or by the molecular expression

$$\boxed{HH}+\boxed{ClCl}=\boxed{HCl}\,\boxed{HCl}$$

The first fact that HCl consists of hydrogen and chlorine gases we prove by the electrolysis of strong liquid hydrochloric acid, having previously shown in the course of the lecture how HCl is obtained from common salt, and that the liquid acid is merely a solution of the gas in water. The decomposing cell, which we use in this experiment, is represented in outline by fig. 1, which is drawn to a scale of $\frac{1}{5}$, so that both its construction and dimensions require no detailed description. The two small open glass cylinders are fitted by grinding with emery to the two tubulatures of the cell, and when the instrument is not in use are closed above with ground glass stoppers. When mounted for use the cell is filled with strong hydrochloric acid to within an inch of the upper mouths of the cylinders, and the glass stoppers are replaced by rubber stoppers, through which pass the gas delivery tubes and the conducting wires connecting with the electrodes, which are two strips of platinum foil four inches long by

1.

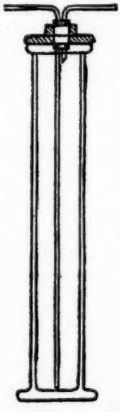


one inch wide. The platinum conducting wires are welded* to the strips of foil and secured in the rubber stoppers as represented in detail by fig. 2. Into the lower end of a short piece of glass tube, which passes tightly through the rubber, the platinum wire connecting with the foil is secured by melting the glass around it, while the upper end is left open to receive the copper conducting wires from the battery, and the connection is made perfect by placing a few drops of mercury in the tube. This simple form of connecting-cup is easily made and very convenient.

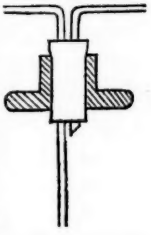
2.

As the conducting power of hydrochloric acid is very good, three Bunsen cells of the ordinary size have ample intensity and give a rapid evolution of gas. The hydrogen gas is conducted into a tall but narrow glass jar mounted in the usual way over a small pneumatic trough, while the chlorine is collected by displacement in a precisely similar jar mounted as represented in fig. 3. The mouth of this jar is closed by a ground glass plate, which is tubulated, as is shown in detail by fig. 4. This tubulature again is closed by a rubber stopper, through which pass first, the delivery tube, which reaches the bottom of the jar, and secondly an overflow tube which merely passes through the stopper, and which in the experiment should be connected by a flexible hose with a ventilator. When a larger amount of chlorine is desired the first jar may be connected with a second, and that with a third, etc., all mounted in the same way, and the exit tube from the last jar leading to a ventilator as before. When the jars are full the tubulated stoppers with their connections are removed and a plain glass cover substituted. This simple form of apparatus will be found very useful in all experiments on gases heavier than the air.

3.



4.



During the process of electrolysis the class will see that the two gases are evolved in nearly the same proportions, the colored gas rising in one jar as rapidly as the water falls in the other. The narrowness of the jar prevents to a great degree the diffusion of the chlorine, and a piece of white paper placed

* The platinum wire is very easily welded to the foil on a smoothed surface of a lump of quick lime which serves as an anvil. The two having been placed together in the required position on this support are first intensely heated at the points to be united, with a blow-pipe flame, and then a quick blow with a small hammer completes the work.

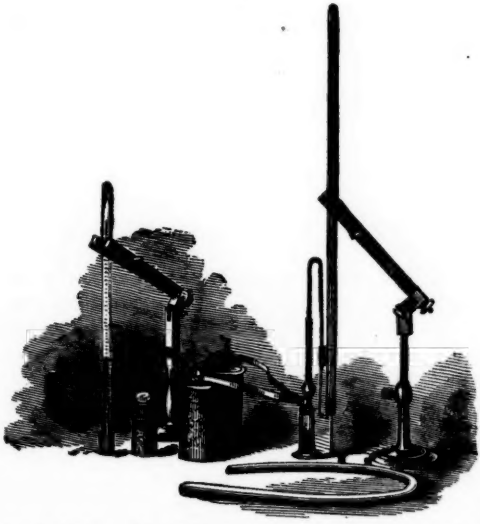
behind the jar, will make the line between the colored gas and the air visible to a considerable distance. When the jars are full, the qualities of the two gases may be made evident by appropriate experiments. As is well known, the gases will not be delivered in atomic proportions, until the liquid acid is saturated with chlorine. It is best therefore not to empty the cell after the experiments, but, having removed the rubber stoppers with their attachments, to close the mouth with the ground glass stoppers, and the apparatus will then be ready for the next occasion. It is also best to interpose a small wash bottle containing sulphuric acid, between the cell and the chlorine jar, for this will not only dry the gas but also equalize the hydrostatic pressure on the two delivery tubes. Decomposing cells like that represented in fig. 1, and all other forms of glassware described in this paper are made by the New England Glass Co., of East Cambridge, and can be ordered through any of the dealers in philosophical apparatus in Boston. A much simpler decomposing cell, although not quite so efficient an apparatus, can be made with a common U tube supported on a wooden stand and mounted with rubber stoppers, delivery tubes and platinum electrodes in every respect like the other.

The second point to be illustrated in regard to hydrochloric acid is, that it consists of equal volumes of its constituent gases; and although by our first experiment, if made in the way we have described, it is shown that the gases are evolved in nearly equal proportions, yet a second experiment is required to establish the absolute truth* of this important fact. The apparatus we use for this purpose is represented in fig. 5, and the details of the several parts are shown in fig. 6. The two gases are evolved together from a simple decomposing cell, shown more in detail in fig. 9, but in connection with another apparatus, and the connection of the battery with the two electrodes, is here made as before shown in fig. 2. The mixed gases pass through a small drying tube filled with pumice moistened with oil of vitriol, into an absorption tube whose construction is shown in detail by fig. 6. As the gaseous mixture is decidedly lighter than air, it is conducted to the top of the absorption tube through the small quill tube, and overflows through the short tube below. Both of these should pass air-tight through the rubber stopper, which closes the mouth of the large absorption tube and

* We here of course leave out of view the small difference which arises from the fact that the gases do not absolutely obey Mariotte's law and are therefore unequally condensed even by the atmospheric pressure. The volumes of the two gases would undoubtedly be exactly equal under greatly diminished pressure, but under the pressure of the air, the volume of the molecular weight of chlorine is about $\frac{1}{100}$ less than the corresponding volume of the molecular weight of hydrogen, a difference by no means inappreciable in accurate experiments.

which should therefore have a bearing on the glass of at least half an inch. It will be noticed that while the overflow tube

5.



6.

is straight, the delivery tube is bent so that its open end is four or five inches above the mouth of the absorption tube. Rubber stoppers, or rather caps, must also be provided, by which the open ends both of the delivery and the overflow tubes may be closed at the right time. These are made by boring with a cork-borer *nearly* through an ordinary stopper and then pulling out the rubber core with a pair of pincers. The absorption tube should now be divided into two parts of equal capacity by means of rubber rings having however a length of three or four inches at the lower end for the absorbent liquid.

The absorption tube having been prepared as described and filled with the mixed gases, the experiment is made in the following way. The apparatus is first rapidly depressed in a solution of caustic soda (of the ordinary strength used in the laboratory) until the liquid rises in the tube to the level of the first ring. The open end of the delivery tube is now quickly closed with the rubber cap, and then the end of the overflow tube is closed in the same way—the second rubber cap having been previously dropped upon the bottom of the glass vessel containing the soda solution so as to be ready for the purpose. The tube, now perfectly air tight, is removed from the liquid and the solu-

tion of soda turned backward and forward through its entire length until the chlorine is wholly absorbed. The end of the overflow tube is now opened under water colored blue with litmus, which, as it rushes in, will be instantaneously bleached, indicating the presence of chlorine. The tube must now be immersed in the water until the level of the liquid is the same within and without, when it will be found that just one-half of the gas has been absorbed. We have now proved that one-half of the volume of gas evolved during the electrolysis of hydrochloric acid consists of chlorine, and it only remains to show that the remaining half still left in the tube is hydrogen. For this purpose the delivery tube may be connected with a water faucet and the gas burnt as it is forced out through the overflow tube.

We have now proved first, that hydrochloric acid is composed of hydrogen and chlorine; secondly, that these gases are present in equal proportions by volume, and in order to complete our demonstration of the constitution of this typical compound, we have only to prove that when these equal volumes unite to form HCl there is no condensation. This we may do either synthetically or analytically.

The synthetical experiment is made by filling the absorption tube as before with the mixed gases obtained by the electrolysis of hydrochloric acid, taking great care, as also in the previous experiment, that the tube should be perfectly dry. It will of course be necessary to have two of these tubes if both experiments are to be made in the same lecture. The tube thus filled is to be exposed for some time to bright diffused sun-light, and afterwards directly to the sun-beam until perfect combination results. If the glass is quite thick, and the rubber stopper is forced in very tight, the gases may even be exploded in the tube without danger, although this form of the experiment is always attended with some risk. When the gases are in either way thoroughly combined, the end of the exit tube is first opened under mercury, in order to prove that no condensation has taken place, and afterwards under water colored blue by litmus, when a very rapid absorption takes place, and the reddening of the water will indicate that HCl has in fact been formed.

The analytical experiment is made by decomposing HCl gas by means of sodium amalgam. For this purpose the carefully dried gas is first collected over mercury in a perfectly dry tube. This tube we assume is graduated, or at least divided into two parts of equal capacity. The tube full of gas is now slipped over the mouth of a rubber cap, which has been previously filled with the amalgam, see fig. 5 (left side of the wood cut), and sunk in the mercury trough until the liquid is just level with

the brim. This cap, which is easily made from the "stopper cord," should be capable of holding ten or twenty cubic centimeters of the amalgam, and should tightly clasp the tube. Moreover for this purpose the solid amalgam, above described, should be reduced with mercury to the consistency of a thin paste. The amalgam is now to be shaken up in the tube for several minutes until the decomposition is complete, and then the mouth of the tube may be opened under mercury. The liquid will rise to supply the place of the chlorine which has been absorbed, and on sinking the tube in the mercury trough until the level is the same within as without, it will appear that exactly one-half of the volume has disappeared. As this, however, would require a deep cistern of mercury, and as the interior surface of the tube is left in such a very dirty condition as to obscure the result, we prefer to transfer the tube to a jar of water, which, when the cap is removed, at once displaces the mercury and washes out the interior, without sensibly impairing the accuracy of the experiment.

Water.—The points to be illustrated in the case of water or rather of free steam are all indicated by the equation

$$\boxed{HH} + \boxed{O} = \boxed{H_2O}$$

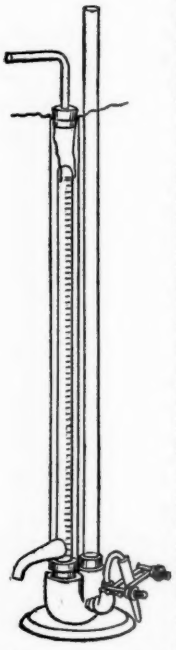
There is no more striking experiment in this connection than the decomposition of water by sodium, but as made in the usual way the experiment is attended with no little danger. Sodium in certain states explodes violently when brought in contact with water, and after several accidents of this sort we have substituted the solid sodium amalgam above described with the best results. We place an ounce or more of this amalgam in a common gas flask and pour upon it water. The action is very moderate and must be assisted by a gentle heat, but on heating the flask with a gas lamp the gas is evolved rapidly and with great regularity. We collect it over the pneumatic trough and illustrate its properties in the usual way.

We illustrate the fact that water is composed of two volumes of hydrogen to every one of oxygen by the electrolysis of dilute sulphuric acid, using for the purpose the decomposing cell, fig. 1, already described. We collect the gases in two tall bell glasses standing side by side on the shelf of the same pneumatic trough. These bells are of course calibrated and the equal divisions marked by rubber rings. Six cells of Bunsen's battery, medium size, give a rapid evolution of gas.

Lastly we illustrate the fact, that when the elementary gases unite to form aqueous vapor, three volumes are condensed to two, by means of the eudiometer represented in fig. 7. This apparatus is easily made with a common iron casting well known

to steam fitters as a "return bend." Any machinist will easily adapt this casting to the required use by attaching to it, as shown in the figure, a circular iron plate to serve as a stand, by also screwing on to one side an ordinary "elbow joint," and at the same time by carefully rimming out the three apertures so as to present smooth surfaces for the adhesion of the rubber stoppers. Into one of the openings of the "return bend" we fasten with a perforated rubber stopper, a common straight *eudiometer tube*, such for example as is ordinarily used in Bunsen's method of gas analysis, while into the second opening we fasten in a similar way an *open* glass tube. In the opening of the elbow joint we secure with a perforated rubber stopper as before, that convenient substitute for a stop cock so well known to chemists as a nipper tap. Last of all we obtain from the glass house a tubulated tube like that shown in fig. 8, of such size that it will cover the eudiometer tube and fit the upper end of the same rubber stopper by which the last is secured in its place. The upper end of this *outer tube* is also closed with a perforated stopper, as shown in the figure, and fine platinum wires, connecting with the wires of the eudiometer, pass between the stopper and the glass. The lower end of the outer tube should not fit too tightly around the rubber stopper so that it can easily be removed when not wanted, moreover all the stoppers should be made of such length that while perfectly tight, they can easily be removed for cleaning the tubes.* These rubber joints, if well made, give great flexibility to the apparatus and enable it to withstand quite rough usage.

7.



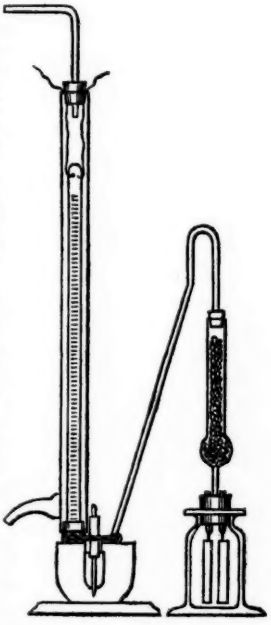
8.

The eudiometer being thus mounted, mercury is first poured into the open limb, which is then closed with a rubber stopper and the mercury transferred by inclining the apparatus to the closed limb, this process being repeated until the eudiometer

* It is also best to place around the upper end of the eudiometer tube a rubber ring, quite narrow, but sufficiently thick to fill the annular space when the outer tube is in its place, and also perforated with a number of small holes, so that the steam or vapor, employed in the experiments, may pass freely. This ring confines the eudiometer tube and gives greater solidity to the apparatus.

tube is full. The excess of mercury is now drawn out of the open tube by the tap and this tube having been removed the instrument is left as represented in fig. 9. The eudiometer is now ready for receiving the mixed gases, which are passed up into it from a simple decomposing cell, as shown in the figure, the excess of mercury overflowing into any convenient vessel. The *open tube* is now replaced and the outer tube secured in position. It is next necessary to raise the temperature of the eudiometer tube to a point considerably above the boiling point of water and maintain it at this temperature during the rest of the experiment. This is most conveniently done by passing through the *outer tube* the vapor of amylic alcohol (fousel oil,) which may be generated in a flask placed at one side and connected by a glass tube with the upper end of the apparatus. The tubulature at the lower end of the tube should at the same time be dipped into the mouth of a glass bottle into which the alcohol may flow as fast as the vapor is condensed, and since the latent heat of this vapor is very small, this simple method of condensation will be found amply sufficient.

9.



As soon as the temperature of the eudiometer tube is constant, which can easily be told, because the mercury column will then remain at a constant height, mercury must be poured into the open tube or withdrawn from it by the nipper tap until the level is the same in both limbs of the apparatus. It remains now only to note the volume of the confined gas and to explode it by passing an electric spark through the platinum wire already noticed, first, however, tightly closing the end of the open tube with its rubber stopper. When the stopper is removed and the mercury columns again brought to the same level it will be found that the volume of the confined gas has been reduced one-third. The result, however, is always a little too small, because aqueous vapor, even at the boiling point of amylic alcohol, 132° C., does not exactly obey Mariotte's law, and is somewhat more condensed than the *mixed gases* by the atmospheric pressure. It would be better to employ the vapor of a liquid having a still

higher boiling point, but the results with amylic alcohol are sufficiently accurate for a lecture experiment.*

Ammonia.—The points to be illustrated in the case of ammonia are indicated by the equation $\boxed{H\ H\ H} + \boxed{N} = \boxed{H_3\ N}$.

We demonstrate the composition of ammonia by the old methods which are familiar to every teacher, synthetically by passing a mixture of nitric oxyd and hydrogen over heated platinum sponge as in the beautiful experiment of the late Dr. Hare, and analytically by decomposing aqua ammonia either by electrolysis or by means of chlorine. For the electrolysis of ammonia the decomposing cell fig. 1 may be used, filling it with the strongest aqua ammonia and adding a not too small amount of sulphate ammonia in order to increase the conducting power of the liquid. The reaction is less simple than in the electrolysis either of water or of hydrochloric acid, but as the final results the gasses are evolved, very nearly at least, in atomic proportions, three volumes of hydrogen to one of nitrogen. They can be collected separately in graduated bells as in the electrolysis of water. In decomposing ammonia by chlorine we use with very satisfactory results the apparatus shown in fig. 6 and already described. For this use however a tube should be selected so thin that water may be boiled in it without risk of breaking the glass. The tube having been filled by displacement with pure and dry chlorine gas, we press down the lower end into very weak aqua ammonia (eight measures of water to one of the concentrated solution,) until the liquid flowing in through the overflow tube rises to the height of the first rubber ring. We now quickly close the delivery tube with its rubber cap and allow the absorption to continue until the tube is about half full of the ammonia water when we also close the overflow tube and shake up the liquid in the large tube until all cloudiness has disappeared from the interior. The decomposition is now complete but a considerable amount of the liberated nitrogen still remains dissolved in the liquid. To expel this we heat the tube carefully over a gas lamp until the liquid within begins to boil. On now transferring the apparatus to the pneumatic trough and opening the overflow tube under water it will be found, when the tube cools, that just one-third of the original volume is left and it can easily be shown that the residual gas

* Indeed we can obtain with free steam a result, which is sufficiently near the theory for all purposes of illustration, only it is then important that both the mixed gases and the resulting vapor should be measured under a pressure considerably less than that of the atmosphere. For this purpose a long eudiometer tube should be used and before each measurement the level of the mercury should be adjusted so that it shall stand in the open tube from 10 to 15 inches lower than in the eudiometer. Of course the difference of level must be the same at both measurements.

is nitrogen. Hence, it follows, since chlorine always combines with its own volume of hydrogen, that ammonia contains only one volume of nitrogen to every three volumes of hydrogen, the point to be proved. To complete this series of illustrations it only remains to show that in ammonia gas the four volumes are condensed to two. For this purpose some dry ammonia gas is passed up into the eudiometer tube as in fig. 9. The side tube is then replaced as in fig. 7, the mercury level adjusted and the position marked with a rubber ring. A stream of electric sparks from a Rühmkorff coil is now passed through the gas, so arranging the connections that the sparks may traverse the whole length of the gas column, and the amount of gas should be small enough to render this possible. The decomposition proceeds somewhat slowly, but after sufficient time on readjusting the level it will be found that the volume of the gas has doubled. Besides the experiments described above, there are many others, to which these same forms of apparatus are applicable; but these will suggest themselves to every teacher and it is not therefore necessary to enter into further details.

Eudiometer.—The eudiometer described above, although originally contrived for the lecture table has proved to be of still greater value in the laboratory, in all processes of gas analysis for which such an instrument is required. It is not only very cheap, simple, and easily repaired, but also equally as accurate as the the most complicated apparatus. It can be used in a room of the most variable temperature; for by passing a current of water, or of steam, as the case may require, through the outer tube the temperature of the eudiometer tube may be easily maintained absolutely constant. The various gases are passed in as shown in fig. 9 and through the same opening the reagents used in the processes of analysis are readily introduced. By replacing the open tube as in fig. 7, and bringing the two mercury columns to the same level, the residual volumes may always be read off under the atmospheric pressure and at a constant temperature, indicated by a thermometer placed in the annular space between the tubes. Or on the other hand by varying the height of the mercury column in the outer tube we may reduce the gas to the same volume and measure the difference of tension according to the method of Regnault. This form of eudiometer is especially adapted for the admirable methods of gas analysis devised by Bunsen. The absorbent balls used by him are most readily introduced when the apparatus is arranged as shown in fig. 9 and the volume of aqueous vapor formed after combustion may easily be measured by replacing the current of cold water through the *outer tube* by a current of free steam. In this case it will be best to measure the gas under as great a difference of pressure as possible, in order to ensure that all the

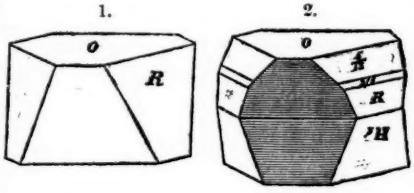
water is vaporized and also in order to avoid the somewhat uncertain correction arising from the difference of temperature of the two limbs of the apparatus. This correction, which in most cases is insignificant, becomes important when steam is used, and it is then best to measure directly the difference of level between the mercury in the open mouth of the iron cistern, fig. 9, and that in the tube. This we do by the millimeter divisions on the eudiometer tube with the aid of a very simple contrivance. A split ring of blackened sheet brass, carrying a bent steel wire, is slipped down over the outer tube until the end of the wire just touches the surface of the mercury. The vertical height of this simple measure being known we have only to add to it the height of the mercury column above the upper edge of the ring in order to know the exact difference of level. Of course care must be taken when the measurement is made that the mercury column is vertical, but it is unnecessary to dwell on such obvious precautions, which are essentially the same with this apparatus as those so fully detailed by Bunsen in his work on "Gasometry." It is obvious moreover that the number of these corrections is considerably diminished in using this apparatus as compared with the ordinary mercury pneumatic trough, and besides the convenience and comfort of working in a warm room, it has the additional recomendation that it requires a very small amount of mercury.

The above apparatus as represented in fig. 9 may also be used with great advantage in Gay Lussac's process of determining the density of vapors. The method of using it is obvious to any one who is familiar with the process. After a weighed amount of the liquid under examination enclosed in a thin glass bulb has been passed up into the eudiometer tube it is readily converted into vapor by passing steam or the vapor of some liquid of a still higher boiling point* through the outer tube. All the measurements required in the determination are now easily made. The temperature is measured by a thermometer placed in the annular space between the two tubes and the difference of level of the mercury in the two limbs of the instrument may be most accurately determined by means of a cathetometer aided by the simple contrivance just described.

* Hydrocarbons of high but still constant boiling points, obtained by the methods of Mr. C. M. Warren, might be used with proper precautions in such determinations.

ART. XIX.—*Crystallographic Examination of some American Chlorites;* by JOSIAH P. COOKE, Jr.

THROUGH the kindness of my friend Prof. Brush of New Haven, I have had the opportunity of examining some unique specimens of the Chlorites from the well known locality at Texas, Lancaster county, Pennsylvania. My observations confirm in almost every particular, those previously made by M. Des Cloizeaux and published in his admirable Manuel de Mineralogie, tome i, pp. 433–451; but the perfection of the crystals at my disposal have enabled me to obtain a greater degree of accuracy in my measurements and also to develop some additional facts, especially by comparing the clinochlore from Texas, Pennsylvania, with that from Chester county in the same state and also with that from Chester in Massachusetts.



Kämmererite or Violet Chrome Chlorite.—The purest crystals of this beautiful mineral have the form represented in fig. 1. They are generally, however, macled and then appear as in fig. 2. Besides the basal plane O and the planes of fundamental rhombohedron R, these crystals also present the planes of several subordinate rhombohedrons of somewhat variable character, and in addition the basal edges of the rhombohedrons are more or less modified by the planes of hexagonal pyramids, but unfortunately the last are so strongly striated and uneven as to be wholly indeterminable. The violet Kämmererite is frequently mixed with green clinochlore, which gives to the crystals a greenish tinge. On these compound crystals the pyramidal planes are much more dominant than on the crystals of pure Kämmererite, and in this way the crystals of one mineral pass into those of the other, the violet rhombohedrons of Kämmererite merging into the green hexagonal pyramids of clinochlore. We give below in column A, the results of measurements of by far the most perfect crystal of Kämmererite we have examined. The angles italicised are certainly accurate to a minute. In columns B_1 and B_2 we give angles measured on two separate zones of a second crystal and these are important as proving the hexagonal character of the crystal. In column C, we give the fundamental angle measured on still a third crystal. The last two crystals were not so perfect as the first, but still the angles italicised must have been measured accurately within two or three minutes; so that

the small differences between these values and those in column A are real variations in the angle, such as are quite common in foliated minerals. All the crystals measured were macled as in fig. 2, and we have distinguished the faces of the two members of the macle by the symbol O, R, etc., for the first, and O_1 and R_1 for the second. It is a fact worthy of notice that the faces of the same subordinate rhombohedrons are not necessarily found on both of the twinned crystals, while those of the fundamental rhombohedron are never wanting. On the first crystal we were able to measure every angle of the zone of planes between the opposite basal planes of the macle, and the observations were verified by repeated measurements. It will be noticed that the corresponding angles on the two crystals composing the macle agree absolutely. From these I have calculated the value of the half vertical axis, and from the last I have deduced the values of the angles in the column headed calculated.

$$a = 3{\cdot}4951$$

	Calculated.	Observed.			
		A	B_1	B_2	C
O on R	103° 55′	**103° 55′**		**103° 41′**	**103° 41′**
O on $\frac{4}{13}$R	128° 51′	128° 59′	129° 6′	**129° 8′**	
O on $\frac{2}{5}$R	121° 47′	121° 54′		122° (nearly)	
$\frac{4}{13}$R on $\frac{2}{5}$R	172° 56′	172° 55′			
$\frac{2}{5}$R on R	162° 8′	161° 59′			
R on R_1	152° 10′	**152° 10′**			
R_1 on O_1	103° 55′	**103° 55′**			
O_1 on O_1	180°	**180°**			
R on R (vertical edge)	65° 36′				

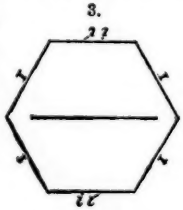
Des Cloizeaux obtained from the same mineral O on R 103° 45′, O on $\frac{2}{5}$R, 122° (about), and from the Pennine of Zermatt for O on R 103° 40′ to 50′.

Optical characters of Kämmererite.—The crystals are *uniaxial*, and the double refraction though *feeble* is distinctly *positive*. The crystals described above as No. 1, showed distinctly the first two rings with the familiar black cross. In white light these rings are alternately blue and pink surrounding a pink-colored center. In homogeneous light the rings formed by the red rays are much narrower than those formed by the blue, indicating the somewhat unusual fact that the crystal exerts the feeblest dispersive power, on the most refracted, in this case the extraordinary, beam. The crystals of Kämmererite are strongly dichroic. By transmitted light in the direction of the optical axis the color is violet; but in all directions at right angles to this, while the color of the ordinary beam is violet, that of the extraordinary is hyacinth-red. Before the blowpipe the mineral gives decided reactions both for chromium and iron.

Pale Green Chlorite.—Accompanying the specimens of Kämmererite I received a single specimen of another variety of Chlo-

rite having a very pale apple-green color. It came from the same locality, but how closely it is associated with the violet mineral, I have not as yet been able to ascertain. The crystals are six-sided plates with an angle of 120° between the lateral edges, and the edges are beveled by the planes of a very acute hexagonal pyramid. With the exception of the color, and the strong dichroism, which is in a measure the result of the color, the optical qualities are essentially the same as those of Kämmererite. The crystals are uniaxial and they present the same *feeble, positive* double refraction. Moreover the rings formed by red light are narrower than those formed by blue light. Before the blowpipe the mineral gives a decided reaction for iron; but only a very faint reaction if any for chromium, and the difference of color is evidently connected with this difference of composition.

Clinochlore from Texas.—Intimately associated and more or less mixed with Kämmererite are crystals of clinochlore which in their purest condition have a brilliant emerald-green color. These crystals of pure clinochlore are double hexagonal pyramids, but the faces of the pyramids, are so irregular and strongly striated that it is impossible to determine the crystallographic elements of the crystals. The crystals cleave easily parallel to the basal plane and they may thus be readily divided into hexagonal plates with an angle of 120° between the lateral edges. These plates show a strong double refraction and the plane of the optical axes is parallel to the edge of the hexagonal section as shown in fig. 3. The bisectrix of the acute angle between the optical axes is positive, and inclined at a variable angle to the normal of the plane of cleavage. The angle between the optical axes is also exceedingly variable. The following angles were measured on cleavage plates from different crystals. These are not of course the true angles; but the great fluctuations of the value makes any reduction of the observations unimportant.



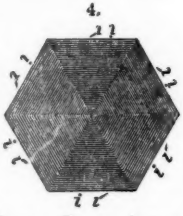
	Apparent angle between optical axes.	Apparent angle between bisectrix and normal.
No. 1,	84°	15° 30′
No. 2,	79°	
No. 3,	67°	13° 30′

The dispersion of the axes is quite evident, and in every case $\rho > v$. Moreover, the system of rings, when seen by white light, shows a slight but distinct difference of form at the two ends, thus indicating that the general dispersion of the system is longitudinal;* and this characteristic further indicates that the crys-

* The modifications in the biaxial system of rings called by Des Cloizeaux "dispersion inclinée," "dispersion horizontale" and "dispersion croisée ou tournante" we

tals belong to the monoclinic system, and that the optical axes are in the plane of symmetry. These crystals of clinochlore also show a marked dichroism. The color by transmitted light in the direction of the optical axis is emerald green but in all directions at right angles to the axis, while the color of the ordinary beam is green, that of the extraordinary is reddish yellow.

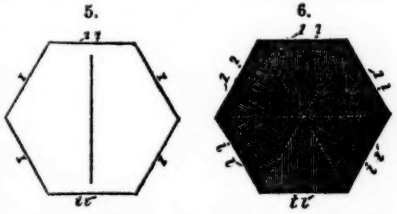
The crystals of clinochlore from Texas are almost invariably macled. The ideal macle, if I may use the term, consists of three crystals interpenetrating each other, as is shown in section in fig. 4 where the portions of different crystals are distinguished by the shading, the lines of the shading indicating also the position of the plane of the optical axes. It is seldom the case, however, if ever, that the macles have the regularity, which our figure would indicate, although I have frequently observed on different parts of the same plate three different systems of rings, the planes of whose axes make angles of 60° with each other. In an intermediate position a complex form would be seen resulting from the overlapping and interfering of the three systems. Generally, however, the crystals are united in very unequal proportions, some one or two being present in very great excess and giving rise to corresponding irregularities in the figures seen by polarized light. With many plates the combined figure just spoken of would alone be seen, while with others you would see over most of the plate only one ring system, a single corner perhaps showing evidence of macling. When, as is frequently the case, the crystals of clinochlore enclose those of Kämmererite the result is still more complex. At times the crystal of Kämmererite forms the nucleus of a larger crystal of clinochlore, while in other cases these two heteromorphous minerals seem actually to interpenetrate each other; and in all cases the cleavage planes of the two crystals absolutely coincide. The crystals of clinochlore thus acquire *a violet tinge* and at the same time the angle between the optical axes is diminished. Moreover we have observed on such crystals a character not unlike that first noticed by De Senarmont on certain artificial crystals and to which he referred the variation in the angle of the optical axes of the micas. Thus on moving a plate of violet tinged clinochlore parallel to itself in front of the polarizing microscope I found that the angle between the optical axis varied as I passed from one side of the field to the other. The successive values which



have named in English longitudinal, lateral and circular dispersion. The English terms are not the exact equivalents of the French words, but they express the idea that the effect of light of different colors is, in the first case to move the system of rings longitudinally, in the second case to move it laterally, and in the third case to revolve it through a small angle around the bisectrix.

I obtained were 27°, 26°, 19° 30′, 18°, 17°, 16°. On another plate beginning with an angle of 30° I next measured an angle of 18°. Moving the plate still farther, always parallel to itself, the axes closed together and then again opened as I passed on to another portion of the macle. It will be noticed that the largest of these angles is much smaller than those observed on crystals of pure clinochlore, and on placing a plate of pure Kämmererite behind a plate of pure clinochlore I observed not only that the angle between the optical axes was diminished but also that the color of the light transmitted through the two plates was precisely the same as that seen through plates of the compound crystals we have been discussing.

Clinochlore from Chester county, Pennsylvania.—In connection with the clinochlore from the Chrome Iron Mines of Texas, Pa., I have reëxamined that from the serpentine of West Chester in the same state. As is well known these large crystals are so exceedingly irregular that the form cannot be accurately determined. Like other crystals of chlorite, they have an easy micaceous cleavage, and the cleavage section is either hexagonal or triangular, the angle between the adjacent edges of the section measuring 120° or 60° as the case may be. The optical characters are in most respects the same as those of the corresponding mineral from Texas. There is the same strong double refraction and biaxial character, the same inclination of the bisectrix to the plane of cleavage, the same variation in the angle between the optical axes, the same system of macles, the same color and the same dichroism; but still there is one important exception. The line uniting the centers of the biaxial image is not parallel but perpendicular to the edge of the hexagonal section as is shown in fig. 5. This fact first observed by Mr. W. P. Blake I have verified on a number of different plates, and I have not been able to find a single exception to the rule. Moreover, this position of the plane of the optical axes is preserved in the macles. An ideal section of such a macle is represented in fig. 6, where as in fig. 4 the position of the plane of the optical axes on different parts of the plate is indicated by the lines of the shading; and in some plates this ideal arrangement is very nearly preserved, although generally we find the same irregularities already noticed on the macles from Texas. Lastly, the dispersion is not *longitudinal* but *lateral*. This dispersion of the biaxial image is so slight, however, that it might be readily overlooked. It is manifested only by a slight difference in the curvature of the rings and in the



intensity of their color on the two sides of the image, but then this difference is constant and after examining a large number of plates placed in different positions in the field of the microscope I was left in no doubt as to the fact. It follows then, that while these crystals are monoclinic and the position of the bisectrix is the same as in the crystals from Texas, the plane of the optical axes instead of coinciding with the plane of symmetry is at right angles to this plane.

Clinochlore from Chester, Massachusetts.—Through the kindness of Dr. C. T. Jackson of Boston I have had the opportunity of examining some well-characterized chlorite crystals, which occur at the emery mine of Chester, Mass., in connection with diaspore and its associated minerals. The crystals are double hexagonal pyramids but very rough and irregular. They have a micaceous cleavage yielding an hexagonal section, and the angle between the adjacent edges of the section measured on two different plates exactly 120°. The optical characters are all those of clinochlore; strong double refraction; biaxial image with the bisectrix inclined to the cleavage plane; and moderate dispersion of the axes $\rho > v$. Moreover the angle between the optical axes is very variable. I measured on different cleavage plates, all from this one locality, the angles 73° 30′, 71° 30′, 45°, 32°. The line joining the centers of the biaxial image is perpendicular to the edge of the hexagonal section, and the dispersion of the image is lateral as in the crystals from Chester Co., Pa. Indeed these crystals resemble the last in almost every respect except that they are smaller, have a deeper color, and are not so generally macled.

Analogies between the Chlorites and Micas.—Although these two minerals crystallize in very different systems, yet the analogies between their crystalline characters is very remarkable. In crystals of both minerals the section made by the cleavage plane is a regular hexagon; in both, the double refraction is strong and the angle between the optical axes is very variable; in both we can distinguish two optically distinct varieties, in one of which the plane of the optical axes has the position shown in fig. 3, while in the other it has the position shown in fig. 5. Lastly Kämmererite and Pennine stand in somewhat the same relation to the two varieties of clinochlore that Vesuvian Biotite stands to the two corresponding varieties of mica, although it must be remembered, that while the double refraction of the uniaxial chlorite is very feeble that of the uniaxial mica is still quite strong. Mineralogists generally admit with DeSenarmont that the variations in the optical axes of the micas result from the mutual influence of the two optical varieties and the facts of this paper tend to show that the same influence is exerted on the chlorites.

Cambridge, June 29th, 1867.

ART. XX.—*Contributions to Chemistry from the Laboratory of the Lawrence Scientific School,* No. 3; by WOLCOTT GIBBS, M.D., Rumford Professor in Harvard University.

§ 1. *On a new general method of volumetric analysis.*

IN a memoir on the quantitative determination of nitric acid, H. Rose* suggested that in particular cases the metal in the nitrate might be precipitated by means of sulphydric acid, and the nitric acid set free determined in the filtrate by volumetric methods. So far as this application of the volumetric analysis is concerned, Rose's method appears not to have been carried out in practice or even supported by actual experiment. It occurred to me that the method might be generalized so as to form the basis of a new application of the processes of acidimetry, and the following analyses will serve to show the degree of accuracy which may be attained. When the salt to be analyzed contains a fixed acid which does not act upon sulphydric acid gas, a weighed portion is to be dissolved in water, the solution brought to a boiling heat and a current of sulphydric acid gas passed through until the metal is completely precipitated. When quantities of about 5 grams are employed the precipitation is usually complete in half an hour. The precipitate may then be allowed to settle and a drop of the supernatant liquid taken out with a glass rod and tested upon a white porcelain plate, with a drop of a saturated solution of sulphydric acid in water, or with any other reagent which may be specially adapted to the metal in the salt examined. The precipitation being complete the liquid is filtered upon a ribbed filter, the filtrate and the washings allowed to flow into a half liter or liter measure, and the washing with hot water continued until a drop of the filtrate no longer exhibits an acid reaction. The liquid is then allowed to cool and the volume made up to exactly a half liter or liter by the addition of water. After thoroughly mixing the contents of the measure, fifty or one hundred cubic centimeters are to be taken out, a few drops of a solution of cochineal or logwood added, and the free acid determined by means of $\frac{1}{10}$ normal ammonia in the usual manner. The first determination is to be used simply as a guide. Two or more successive portions of the acid liquid may then be taken out and determined successively, and the mean of several determinations obtained. With very little practice the results will be found to correspond to $\frac{1}{10}$ c. c. when a burette with Erdmann's swimmer is employed. From the quantity of ammonia required to neutralize the acid, the quantity of acid, and in many cases also of base, in the salt may be readily calculated.

* Pogg. Ann., B. cxvi, p. 125.

With crystallized sulphate of copper the following results were obtained.

1·8435 gr. sulphate gave 31·89 p. c. acid and 31·70 p. c. base (Sharples)
3·7183 gr. " gave 32·14 " " and 31·93 " " (Sharples)
8·3955 gr. " gave 32·10 " " and 31·89 " " (Tower)

The formula $CuSO_4+5aq$ requires (Cu=63·50).

		I.	II.	III.
CuO,	31·86	31·70	31·93	31·89
SO_3,	32·07	31·89	32·14	32·10

The first analysis was made with a commercial sulphate, the other, with a pure salt prepared from electrotype copper. In crystallized sulphate of copper and potassium, ($CuSO_4+K_2SO_4+6aq$.) 2·6601 gr. gave 18·23 per cent acid and 18·11 per cent oxyd of copper. The formula requires

		Found.
CuO,	18·00	18.11
SO_3,	18·12	18·23

In the memoir already referred to Rose points out the necessity of diluting the solutions of metallic nitrates to such a degree that the nitric acid set free shall not act sensibly upon the sulphydric acid.

In the experiments made in my laboratory to test the method this precaution was not found to be sufficient. Thus with crystallized nitrate of lead, Mr. Sharples obtained the following results.

I. 2·147 grams of salt were dissolved in 200 c. c. water and the lead precipitated from the boiling solution by sulphydric acid gas. The filtrate was made up to 500 c. c. of which three portions containing each 75 c. c. were taken for titrition and each required 18·2 c. c. of ammonia. This gives 30·51 per cent of nitric acid, while the formula $Pb(NO_3)_2$ requires 32·61 per cent.

II. 2·4992 of the nitrate were dissolved in 500 c. c. of water and treated as above, only the lead was thrown down in the cold by sulphydric acid, and the excess of the latter expelled from the filtrate by boiling. The acid found corresponded to 32·12 per cent in place of 32·61. From this it is clear that even dilute nitric acid acts too powerfully upon sulphydric acid to permit a very accurate determination of the former under the circumstances of the experiment. Precipitation from a boiling solution is necessary because the filtrate is then at once free from sulphydric acid.

To obviate the difficulty arising in the case of nitric acid it occurred to me to add to the solution of the nitrate a portion of a neutral salt containing a fixed organic acid, an equivalent quantity of which would be set free by the combination of the free nitric acid with the base contained in the salt. This method

was found to give perfectly satisfactory results, as the following analyses by Mr. S. P. Sharples will show.

4·409 grams of nitrate of lead were dissolved in 200 c. c. of water, five or six grams of pure Rochelle salt added and the lead precipitated as above. The quantity of acid found corresponded to 32·58 per cent. The formula $Pb(N\Theta_3)_2$ requires

		Found.
$N_2\Theta_5$,	32·63	32·58
$Pb\Theta$,	67·37	67·27

0·9380 gram of nitrate of bismuth were treated as above, Rochelle salt being added. The nitric acid found, corresponded to 33·40 per cent and the equivalent quantity of oxyd of bismuth to 47·82 per cent. The formula $Bi(N\Theta_3)_3+10aq$ requires

		Found.
$N_2\Theta_5$,	33·47	33·40
$Bi_2\Theta_3$,	47·94	47·82

5·6553 gr. of chlorid of mercury were treated as above, six or eight grams of Rochelle salt being added to the solution. The free acid corresponded to

	Calc.	Found.
Cl_2,	26·20	26·10
Hg,	73·80	73·90

When chlorine is separated in the form of chlorhydric acid the volatilization of the acid in the process of boiling is completely avoided by the addition of the organic salt. The same remark applies to nitric acid, though it is probable that the principal cause of loss in this case is the action of the acid at a boiling heat upon the gas passed through the liquid. The precipitation of a metal by sulphydric acid is usually much slower when boiling solutions are employed.

The analyses given above show that, under favorable circumstances, the method employed is capable of giving satisfactory results. It is easy to see that it applies in the case of soluble definite compounds of all those metals which are easily and completely precipitated from boiling solutions by means of sulphydric acid gas. When the compound to be analyzed contains an excess of free acid not combined with the oxyd of the metal to be determined, this must be first separated by evaporation to dryness in the usual manner. The presence of alkalies and alkaline earths is of course without influence on the result, but on the other hand even very small quantities of iron, alumina and various other bases make it almost impossible to determine the point of saturation with precision, these oxyds in solution giving with cochineal and logwood specific reactions not easily distinguished from those produced by the alkalies in excess. For this reason the method does not apply when oxyds of this class are present, and this case is precisely that which

most frequently occurs in practice. The method will be applicable to all these cases if hereafter a coloring matter should be discovered sensitive only to acids or bases in excess, but not producing specific coloration with salts which are neutral in constitution. It is possible that cyanin, the remarkable properties of which have been described by Schönbein, or the rosocyanin of Schlumberger,* may fulfil the condition indicated, but I have had no opportunity of experimenting with either.

The method of precipitation above described may be used with advantage in preparing a pure normal acid for titrition. Pure crystallized sulphate of copper is to be powdered and heated in a porcelain crucible placed within a Hessian crucible for about an hour, the temperature being gradually raised and not allowed to exceed a low red heat. The anhydrous sulphate is then while still hot to be transferred to a perfectly dry glass tube which can be closed with a good cork covered with tin foil. After cooling, the tube is weighed, the contents poured into a flask, the salt dissolved in water and the copper precipitated at a boiling heat as above. The filtrate and washings are then to be made up to a known volume. From the weight of the anhydrous sulphate employed the quantity of sulphuric acid present in the solution is known. In experiments made in this laboratory by Mr. R. Chauvenet this method has been found very accurate and expeditious.

§ 2. *On the precipitation of copper by hypophosphorous acid.*

In a memoir on the hypophosphites, A. Würtz† has shown that when solutions of copper are heated to 70° C. with hypophosphorous acid a hydruret of copper is precipitated, which on boiling is reduced to metallic copper with evolution of hydrogen. On repeating this experiment I found that the precipitation of copper is complete, and as the alkaline hypophosphites are now to be had in commerce, it appeared probable that the process might be applied to quantitative estimation. Experiments to determine this point have been made by Mr. R. Chauvenet with the following results:

The copper should be in solution as sulphate, the liquid containing a little free acid. The precipitation from the nitrate is always incomplete. When chlorhydric acid or chlorids are present the method fails entirely, the copper being reduced to subchlorid and remaining in solution. The solution must not be too dilute; the precipitation is complete if the saturated solution of sulphate be diluted with not more than ten times its bulk of water, before the addition of the hypophosphites. In order to avoid the sudden evolution of hydrogen gas, and also to ob-

* Bull. de la Société Chimique, Mars, 1866, p. 194.

† Ann. de Chimie et de Physique, 3d series, vol. vi, p. 199.

tain the precipitate in a spongy coherent form, it is best not to allow the liquid to boil. The solution of hypophosphite having been added in the cold and in excess, the temperature is to be gradually raised until, after standing for some minutes between 80° C. and 90° C., the hydruret of copper has entirely separated in coherent masses. It is easy to determine when the precipitation is complete by taking out a drop of the clear liquid with a rod and testing upon a porcelain plate with a drop of sulphydric acid solution. No filter need be used if the precipitation be effected in an assay flask; the copper is easily washed by decantation, and may then be transferred to a porcelain crucible by the well-known method of inversion, dried and gently ignited in a current of hydrogen. The following analyses will serve to illustrate the accuracy of this method. In all of them hypophosphite of magnesium was employed as the precipitant.

1.	1·1650 gr.	pure sulphate of copper	gave	0·2965 gr.	copper	=25·45 p. c.	(Chauvenet.)
2.	1.5590 gr.	"	"	0·3970 gr.	"	=25·45 "	"
3.	1·4255 gr.	"	"	0·3625 gr.	"	=25·43 "	"
4.	1·3050 gr.	"	"	0·3327 gr.	"	=25·42 "	(R.B.Carman)
5.	0·8208 gr.	"	"	0·2087 gr.	"	=25·42 "	(E. F. Gale.)

In (4) and (5) a large excess of sulphate of nickel was present.

The formula $CuSO_4+5aq$ gives 25·42 per cent of copper. In the third analysis sulphates of iron, manganese, nickel and zinc in very large excess were added to the solution of copper.

I. In a very pure subsulphid of copper from Arizona, Mr. Chauvenet found in four analyses 74·24, 74·37, 74·36 and 74·41 per cent copper.

II. In an alloy of copper and nickel

6.	0·4245 gr.	gave	0·3605 gr.	of copper	=84·92 per cent.	(Chauvenet.)
7.	0·3615 gr.	"	0·3070 gr.	"	=84·92 "	"
8.	0·1380 gr.	"	0·1170 gr.	"	=84·85 "	"
9.	0·1980 gr.	"	0·1680 gr.	"	=84·84 "	"

III. In brass wire

10.	1·6300 gr.	gave	1.0705 gr.	of copper	=65·67 per cent.	(Chauvenet.)
11.	1.8655 gr.	"	1·2240 gr.	"	=65·61 "	"
12.	1·6770 gr.	"	1·1010 gr.	"	=65·65 "	"

In the last seven analyses the alloy was dissolved in sulphuric acid, nitric acid being added from time to time to assist in solution. The solution was then evaporated until the last traces of nitric acid were expelled. The presence of iron in the form of sulphate does not in any way interfere with the complete precipitation of copper by hypophosphite of magnesium. When sesquichlorid of iron is present, however, the copper is always reduced to subchlorid and is not precipitated as metal or hydruret. A solution of a hypophosphite reduces sesquichlorid of iron to protochlorid: the reduction is particularly rapid and com-

plete when a salt of copper is also present and the liquid contains free chlorhydric acid. I have endeavored to base upon this reduction a method for determining iron volumetrically, but all the experiments failed in consequence of the difficulty of determining the exact point at which the reduction of the iron is complete. Sulphocyanid of potassium, proposed for this purpose by Winkler* in his process with subchlorid of copper as a reducing agent, was not found to give sharp indications. When copper and iron are present together as chlorids, the addition of hypophosphite of magnesium simply reduces the copper to subchlorid as above stated. If in this case we add an alkaline chlorid to keep the subchlorid of copper dissolved, the copper may be easily precipitated as subsulphid by sulphydric acid gas. When arsenic or antimony are present with copper these must first be separated before precipitating the copper as hydruret, as careful experiments by Mr. C. Lilly have shown that both arsenic and antimony are precipitated with the copper. Mr. Lilly obtained the following analytical results when arsenous acid was present.

1·2690 gr.	sulphate of copper gave	0·3279 gr.	metallic copper	=25·83	pr. ct. copper.
1·5127 gr.	" "	0·3905 gr.	"	=25·77	" "
0·9638 gr.	" "	0·2509 gr.	"	=26·03	" "

The formula gives 25·42 of metallic copper. In presence of antimonious acid—

0·7100 gr. sulphate of copper gave 0·2454 gr. copper = 34·56 per cent.

After addition of $Sb_2\Theta_3$ and Rochelle salt

0·9875 gr. sulphate of copper gave 0·2426 gr. copper = 24·56 per cent.

Repeated analyses by Mr. Lilly also showed that copper could not be determined accurately in Schweinfurt green by hypophosphite of magnesium, and that the presence of Rochelle salt did not completely prevent the precipitation of arsenic with the copper when arsenous or arsenic acid were mixed with sulphate of copper.

In assaying copper ores it is usually desirable to bring the metal at once into the form of sulphate. Numerous experiments made in this laboratory fully justify me in recommending the following method. The finely pulverized ore (sulphids of copper and iron) is to be mixed in a porcelain crucible with three or four times its weight of a mixture of one molecule of bisulphate and one of nitrate of potassium. The mixture is then to be slowly heated to low redness, which is best accomplished in a muffle. The metallic sulphids are completely oxydized without the least frothing of the heated mixture. Enough strong sulphuric acid to convert all the sulphate of potassium into bisul-

* Zeitschrift für Analytische Chemie, Bd. iv, p. 423.

phate is then added, and the crucible is to be again carefully heated until the contents run to a clear fused mass. On cooling the mass usually separates readily from the crucible which is not attacked, and on solution the iron and copper are found completely converted into sulphates. This process has been tried successfully with a great variety of ores. The whole operation requires about an hour. In the case of ores containing much bisulphid of iron it is best to heat the powdered ore first as long as sulphur is given off, and afterward to add the oxydizing mixture and heat as above. The sulphids of lead, zinc and antimony are completely oxydized by the same process.

§ 3. *On the precipitation of copper and nickel by alkaline carbonates.*

The precipitation of copper by zinc or by the electrolytic method requires that the metal should be present in the form of sulphate or chlorid and does not succeed with the nitrate. As stated above the employment of the hypophosphites is limited to the case in which the metal exists as sulphate. The old mode of precipitating copper as oxyd by caustic potash has disadvantages which are familiar to all chemists, but on the other hand is independent of the nature of the solution of copper employed so long at least as no organic matter is present. According to Rose* the alkaline carbonates precipitate copper less completely than caustic alkalies. This statement, however, is not accurate for *all* the conditions under which the experiment may be performed; and I have found that copper may be completely precipitated from the sulphate, nitrate or chlorid when the solutions are boiled together for a sufficient time and are sufficiently dilute. Mr. E. R. Taylor, who has made a careful study of this method of determining copper, has arrived at the following as the best method of conducting the process. The solution of copper is to be diluted with water until the liquid contains not more than about one gram of the metal in one litre. A solution of carbonate of potash or soda is then to be added in small excess, and the whole boiled for about half an hour. The boiling proceeds quietly and without succussions; the blue green carbonate soon becomes dark brown, and has a fine granular character which renders it extremely easy to wash. After washing it is to be ignited in an atmosphere of hydrogen, and the copper weighed as metal; it will be found to be free from alkali. In this manner Mr. Taylor obtained in five analyses the following results:

1·8384 gr.	pure sulphate of copper	gave	0·4688 gr.	metallic copper	=	25·44	pr. ct.
1·7144 gr.	"	metallic cop. dissolved in aqua regia	gave	1·7161 gr.	cop.	=	100·09	p. c.
1·3860 gr.	"	"	"	"	"	1·3853 gr.	"	= 99·93	"
1·4657 gr.	"	"	"	nitric acid	"	1·4670 gr.	"	= 100·09	"
1·4685 gr.	"	"	"	"	"	1·4634 gr.	"	= 99·65	"

* Handbuch der Analytischen Chemie, ii, 175. Sechste Auflage.

The filtrate is perfectly free from copper if the process has been well conducted.

The ignited oxyd is in a state of great subdivision, and the ignition must therefore be conducted with much care to avoid loss. A small portion of the oxyd or basic carbonate usually adheres to the sides of the vessel in which the boiling takes place. This is to be re-dissolved, and again precipitated, but great care must be taken not to add a large excess of the alkaline carbonate, which gives a solution from which the copper is not precipitated by boiling.

Nickel may be completely precipitated from its solutions by precisely the same process. The green basic carbonate may be washed much more readily than the oxyd precipitated by caustic alkali; it is to be ignited and weighed as oxyd. In two analyses Mr. Taylor obtained the following results.

1·9808 gr. anhydrous sulphate of nickel gave 0·9551 gr. $Ni\Theta$=37·79 p. c.
1·4601 gr. " " " " 0·7008 gr. $Ni\Theta$=37·64 "

The formula $\aleph iS\Theta_4$ requires 37·69 ($\aleph i$=58). Dr. F. A. Genth informs me that he has also used the alkaline carbonates in precipitating nickel, and with most satisfactory results.

The precipitation of cobalt by an alkaline carbonate can only with much difficulty and by long boiling be made complete. As a means of determining cobalt it is not to be recommended. On the other hand Mr. F. W. Clarke has found that cobalt is completely and easily precipitated by the process of oxydation first given by Popp,* which consists in neutralizing the solution with carbonate of sodium, adding acetate of sodium and then boiling with an excess of an alkaline hypochlorite, taking care to keep the solution alkaline. The hydrated sesquioxyd (?) of cobalt thrown down may be readily washed. After reduction in hydrogen the metal is found to be free from alkali. Nickel may, as Popp has also shown, be precipitated in the same manner, but the process given above seems to me preferable.

In this connection I may be permitted to state that the method of separating cobalt from nickel by means of peroxyd of lead attributed to myself in the new edition of Rose's† Handbuch der Analytischen Chemie and also ascribed to me by Gauhe‡ was never even proposed by me.

Cobalt and nickel may be precipitated from neutral solutions of their sulphates, nitrates and chlorids by adding first an excess of oxalic acid to the concentrated solution and then a large excess of strong alcohol. After standing a few hours the filtrate is perfectly free from metal. The oxalates are very easily washed. This method is, however, rarely available for analyt-

* Zeitschrift für Analytische Chemie.
† Sechste Auflage, Bd. ii, p. 143.
‡ Zeitschrift für Analytische Chemie.

ical purposes, since it fails entirely when salts of ammonium or of the alkaline metals are present. The oxalates are also in such a state of subdivision that it is almost impossible to ignite them without loss. The oxyds of copper, cadmium, zinc, manganese and magnesium, are also completely precipitated from their sulphates by oxalic acid and alcohol, but not in presence of alkaline salts. The same is true of both mercurous and mercuric nitrates. In the few cases in which this mode of precipitation will find application in practice it will probably be best to determine the oxalic acid in the oxalate by hypermanganate of potash.

In a former paper I have stated that the sulphids of cobalt and nickel thrown down from boiling solutions by a boiling solution of sulphid of sodium may be washed without oxydation upon the filter. The difficulty of preparing pure sulphid of sodium has, however, been an objection to this method.* This difficulty may easily be removed by dissolving the crystallized tetrahedral sulphid, Na_2S+9aq, in alcohol of 90 per cent, filtering and allowing the solution to crystallize. After two or three crystallizations the pure sulphid may be dried over sulphuric acid in vacuo and the white effloresced mass preserved in a well stoppered bottle. The sulphid is chemically pure.

§ 4. *On the employment of sand and glass filters in quantitative analysis.*

Sufficient attention has not been paid to the advantages of filters of sand and glass over those of paper, when precipitates are to be dried upon the filter at a definite temperature. By choking the throat of a funnel with coarse fragments of glass and then placing upon these successive layers of powdered glass or sand, the upper layer being of the finest powder, it is easy to make a filter upon which almost any precipitate may be filtered off and washed out completely without the slightest loss. The funnel with its contents may then be dried at any temperature below that at which the glass softens or at which the precipitate undergoes chemical or physical change. Mr. E. R. Taylor, who has carried out this suggestion with the greatest care and thoroughness, obtained the following results in three analyses of tartar-emetic.

I.	0·0917 gr.	tartar-emetic gave	0·0463 gr.	Sb_2S_3	= 36·09	per cent	Sb.
II.	0·6236 gr.	"	0·3149 gr.	"	= 36·08	"	"
III.	0·1766 gr.	"	0·0891 gr.	"	= 36·07	"	"

The formula requires 35·92 per cent (Sb=120).

In the first and second analyses the precipitated sulphid was dried at 375° C. In the third the funnel had the shape of a tube

* This Journal, vol. xxxvii, p. 350, also Zeitschrift für Analytische Chemie, Bd. iii, p. 392.

tapering at one end and dilated in the middle to a sort of bulb, and the precipitated sulphid of antimony after drying was ignited in the filter tube itself in a current of carbonic acid gas. This form of funnel, which is due to Mr. Taylor, will be found very advantageous. A small common funnel may be inserted into the top, and after drying, the tube funnel closed with a cork in weighing.

§ 5. *On the estimation of manganese as pyrophosphate.*

The existence of an ortho-phosphate of manganese and ammonium corresponding to the well known salt of magnesium, was long since ascertained by Otto.* The subject has more recently been studied by Debray† who has described a series of analogous phosphates, all of which are remarkable for their insolubility. Otto's salt, $P_2O_8Mn_2(NH_4)_2+2H_2O$, from its highly crystalline structure, the facility with which it is formed, and its insolubility, appeared well adapted to the quantitative estimation of manganese, and the following analyses show that this metal like magnesium may be advantageously precipitated as ammonia-phosphate and weighed as pyrophosphate.

To the solution of manganese, which may contain salts of ammonium or of the alkaline metals, disodic orthophosphate is to be added in large excess above the quantity required to precipitate the manganese as orthophosphate. The white precipitate is then to be redissolved in excess of sulphuric or chlorhydric acid, heated to the boiling point and ammonia added in excess. A white or semi-gelatinous precipitate is produced which, on boiling or standing for some time even in the cold, gradually becomes crystalline and finally is completely converted into beautiful talcose scales which have a pearly luster and a pale rose color. It is best to precipitate each time in a platinum vessel in which the ammonia-phosphate may be boiled for ten or fifteen minutes, and to allow the salt to remain at a temperature near the boiling point of the liquid for an hour after it has become crystalline. The ammonia-phosphate may then be filtered off and washed with hot water. The washing takes place with extraordinary facility on account of the crystalline character of the salt. The orthophosphate after drying and ignition yields pyrophosphate of manganese as a nearly white powder. In this manner

1. 0·9555 gr.	$MnSO_4$	gave	0·8985 gr.	$P_2O_7Mn_2$	= 46·68	p.c.	MnO
2. 1·1400 gr.	"	"	1·0717 gr.	"	= 46·67	"	"
3. 0·8145 gr.	"	"	0·7646 gr.	"	= 46·63	"	"

(Chauvenet.)

* Bull. de la Société Chimique. Nouvelle Série ii, p. 11.
† Ann. der Chemie und Pharmacie, viii, 173.

4. 0·9464 gr. $MnSO_4$ gave 0·8886 gr. $P_2O_7Mn_2$ = 46·66 p. c. MnO
5. 1·3181 gr. " " 1·2390 gr. " = 46·68 " "
6. 1·0565 gr. " " 0·9950 gr. " = 46·76 " "

(Gordon.)

The formula requires 46·67 per cent (Mn = 54). The sulphate employed was pure and perfectly anhydrous. In two analyses of crystallized chlorid of manganese not quite free from mechanically mixed water, Mr. F. W. Clarke obtained 27·08 and 27·07 per cent of manganese. In the same salt the percentage of chlorine was found to be 35·68 which corresponds to 27·14 per cent of manganese.

The advantage of this method over that commonly employed for the estimation of manganese, is that the process permits us to weigh the metal in the form of a perfectly definite compound and not as an oxyd which cannot be safely assumed to consist wholly of Mn_3O_4. When manganese is associated with the alkaline earths it is of course first to be separated as sulphid, or by Schiel's method as a hydrate of the sesquioxyd. The ammonia-phosphate is almost absolutely insoluble in boiling water, in ammonia and in solutions of salts of ammonium. The salt is nearly white but sometimes becomes a little more red upon the filter. If it assumes a rather deep dull red color the whole of the phosphate of manganese has not been converted into ammonia-phosphate. The precipitate is then to be redissolved in dilute chlorhydric acid, more phosphate of sodium added and then ammonia in excess, after which the boiling is to be repeated. This repetition is very rarely necessary, a little practice enabling the analyst to judge when the conversion from the flocky-gelatinous to the crystalline condition is complete. The filtrate from the crystalline salt is perfectly free from manganese. Phosphoric acid cannot be determined by precipitation as ammonia-phosphate of manganese, because the crystalline character of the salt upon which the success of the process depends is only produced by digestion with an excess of phosphate. Bette* has described an ammonia-phosphate of zinc which, like the corresponding manganese salt, is almost absolutely insoluble in water. Debray† has analyzed similar salts of nickel and cobalt, and Otto‡ has also described the analogous ammonia-phosphate of iron. I have myself prepared an ammonia-phosphate of cadmium which, like the other salts of this group, is extremely insoluble in water. All of these salts however, are more or less readily soluble in ammonia and in salts of ammonium, and after repeated trials I have not succeeded in rendering any of them available for analytical purposes.

Cambridge, June 20th, 1867.

* Ann. der Chemie und Pharmacie, xv, 129. † Loc. cit.
‡ Ann. der Chemie und Pharm. xvi, 199.

ART. XXI.—*Note on the action of peroxyd of manganese upon uric acid;* by C. GILBERT WHEELER.

THE oxydizing action of the peroxyds upon organic substances varying to some extent according to the peroxyd employed, I have investigated the action of peroxyd of manganese upon uric acid.

If uric acid and peroxyd of manganese are heated together with a like quantity of water and sulphuric acid is added in small portions at a time until no further action is to be observed, the black pasty mass then filtered, and the filtrate evaporated to about one-fourth of its original volume, there is obtained after considerable time, a quantity of large hexagonal crystals, which by analysis and characteristic reactions was found to be parabanic acid.

If uric acid is heated with a large quantity of water only, until the latter is brought to the boiling point and then peroxyd of manganese added as long as evolution of carbonic acid occurs and the mass filtered, there remains on the filter peroxyd of manganese and oxalate of manganese, while the filtrate on being somewhat concentrated yields crystals, which if again dissolved and treated with animal charcoal may be obtained colorless and quite pure. They were tasteless, rather difficultly soluble in cold but readily soluble in warm water; the solution gave with chlorid of mercury no precipitate, while a very voluminous one was obtained on adding the nitrate of the same base; nitrate of silver and ammonia gave a white glistening precipitate; on heating, cyanid of ammonium was evolved.

0·3595 grams yielded on combustion 0·133 water and 0·398 carbonic acid; which relation indicated the substance to be *allantoin.*

	Found.	Theory.
C	30·13	30·4
K	4·09	3·8

The mother-liquor contained much urea, also an amorphous substance; the quantity of which was too trifling to admit of an analysis. The action of the peroxyd of manganese may be explained by the following exquation.

$$3(C_{10}H_4N_4O_6)+6MnO_2+8HO=2(C_8H_6N_4O_6)+2(C_2O_2H_4N_2)+4(MnO, C_2O_3)+2(MnO, CO_2).$$

If uric acid is heated with peroxyd of manganese in the presence of but a small quantity of water there is formed urea, oxalic and carbonic acid, and but a very small quantity of allantoin; the action of peroxyd of manganese upon uric acid resembles therefore very closely that of peroxyd of lead.

ART. XXII.—*Contributions from the Sheffield Laboratory of Yale College.* No. XV.—*Observations on the native hydrates of Iron;* by GEORGE J. BRUSH, *with analyses of Turgite by* CHARLES S. RODMAN.

THE well known iron mines of Salisbury, Conn., have long enjoyed a reputation among mineralogists as furnishing superior specimens of *limonite*, and hitherto this has been thought to be the only ferric hydrate occurring in quantity at this locality. Minute crystals of supposed Göthite have occasionally been found, but not in quantity sufficient to render certain their mineralogical determination.

On a recent visit to these mines Mr. Rodman obtained a considerable number of specimens, lining pockets in the ore, which had the usual brilliant metallic luster on the interior surface, and showed on the fracture a fibrous structure, but differed from brown hematite in having a decidedly red color, and in affording when pulverized a red powder, closely resembling that of ordinary red hematite. This red layer was in some cases an inch or more in thickness, and was deposited on a bed of limonite (brown hematite); the line of demarcation between the brown and the red ore was so perfect, in most instances, as to readily admit of a complete separation of the two minerals.

An examination of this red ore showed it to be an oxyd of iron, containing not far from five per cent of water, a number of specimens yielding very uniform results; and a complete analysis proved the mineral to be a ferric hydrate with the formula Fe^2H, identical with the *Turgite* of Hermann,* and with Breithaupt's *hydro-hematite*, as analysed by Fritzsche.† The physical characters are so nearly those of ordinary anhydrous hematite that it is difficult to distinguish the species without having recourse to an estimation of the loss on ignition. The turgite yields an abundance of water when heated in the closed tube, and it decrepitates in a remarkable manner. Hardness, about 5·5. G.=4·14. For analysis the mineral was carefully dried over sulphuric acid until of constant weight, and this dessicated mineral was then heated for several hours in an air bath at 100° C. without showing any further diminution of weight. The amount of hygroscopic moisture abstracted from the air-dried mineral by treatment in the dessicator was 1·40 per cent. The iron in one instance was determined by titration with permanganate of potash; in the second case it was thrown down by ammonia, the precipitate washed, dried and weighed, and then the iron was separated from the silica and alumina by Deville's

* Journal für praktische Chemie, xxxiii, 97.

† Breithaupt, Vollständiges Handbuch der Mineralogie, iii, 846.

method by first reducing with hydrogen, and subsequently volatilizing the iron by heating in a current of dry hydrochloric acid gas. The analytical results were all obtained by Mr. Rodman. Composition:

	1.	2.	Mean.
Ferric oxyd, - - -	91·45	91·29	91·36
Manganic oxyd, - -	0·67	0·55	·61
Alumina, - - - -	0·75	....	·75
Silica, - - - -	0·22	0·24	·23
Phosphoric acid, sulphuric acid and cobaltic oxyd,	traces	....	traces
Insoluble in acid, - -	1·83	....	1·83
Water, - - - -	5·20	5·21	5·20
	100·12		99·98

Other determinations of water on different specimens gave 5·02 and 5·09 per cent.

Five grams of the mineral yielded only minute traces of sulphuric acid, and three grams showed but an unweighable trace of phosphoric acid. A very perceptible trace of cobalt was found even on examination of one gram of the mineral. The portion insoluble in acid proved on analysis to consist entirely of silica, and excluding this, with the small amount of silica and alumina found in the soluble portion, the result of the analysis is

	Fe	Mn	H	
	94·00	0·63	5·35	= 99·98
Oxygen,	28·20	0·19	4·75	
	28·39			

giving the oxygen ratio 6 : 1 or Fe^2H.

This result confirms the conclusions of Hermann and Breithaupt that there is a native ferric-hydrate with one-half an equivalent of water. Several years since the attention of the writer was called to this subject by Prof. W. T. Roepper, of Bethlehem, who stated that he had found Breithaupt's hydrohematite to be of frequent occurrence with the limonite ores of the Lehigh valley. A water determination on the Lehigh mineral made by Prof. Roepper, and kindly communicated for this article, gave 5·34 per cent, and Prof. Roepper calls especial attention to the characteristic decrepitation of this mineral when heated. On examination of the specimens of limonite in the Yale College collection, a fine specimen of the red hydrate was found occurring with the limonite of Düsseldorf in Prussia, this yielded on examination by Mr. Rodman 4·75 pr. ct. water. Another specimen was found from Ioditz in Bavaria, besides numerous specimens from Salisbury in Connecticut. A mineral of like composition has also been found by Bergemann* at the Louisa Mine near Horhausen in Prussia. From these numerous

* Rammelsberg, Handbuch für Mineralchemie, 988.

localities it would appear that the mineral is of common occurrence. It has heretofore been confounded by most mineralogists with hematite which it so strongly resembles in physical characters. It may be readily distinguished from hematite by simply heating a fragment in the closed tube, when it decrepitates violently and gives off a large amount of water.

Hermann does not give the pyrognostic characters of *turgite*, but Breithaupt in his description of *hydro-hematite* makes particular mention of its characteristic decrepitation when heated. The turgite is described by Hermann as being associated with copper ores; its chemical composition is however identical with hydrohematite, and as it has priority of publication the species must bear the name of turgite, and hydrohematite be used only as a synonym.

We have therefore three well defined hydrates of iron occurring native and forming three distinct and well-established mineral species, differing from each other in physical characters and in their relative content of water.

Turgite,	$\dot{F}e + \frac{1}{2}\dot{H}$
Göthite,	$\dot{F}e + \dot{H}$
Limonite,	$\dot{F}e + 1\frac{1}{2}\dot{H}$

Two other hydrates have been described containing respectively two and three atoms of water. Murray* found in a brown iron ore from Hüttenrode in the Hartz—

$\dot{F}e$ 81·41, $\dot{H}$ 17·96, $\ddot{S}i$ 0·17, Carbon 0·46=100, giving the formula $\dot{F}e+2\dot{H}$.

A compound of similar composition from Kilbride in Ireland, having a pitchy color, analyzed by Haughton, gave—

$\dot{F}e$ 77·15 $\dot{H}$ 20·48 $\ddot{S}i$ 0·30 $\dot{A}l$ *tr.* $\dot{P}$ 1·60 = 99·48

Xanthosiderite also appears to be a mineral of like composition, but its mixture with a silicate of unknown composition renders it difficult to conclude positively that it belongs here.

A. H. Church† has analyzed a stalactite of a rust-colored ferric hydrate from Botallack mine in Cornwall, which gave—

$\dot{F}e$ 73·73, $\dot{H}$ 24·40, loss, $\dot{P}$, and organic matter 1·76 = 100, giving the formula $\dot{F}e + 3\dot{H} = \dot{F}e$ 74·77, $\dot{H}$ 25·33.

Other analyses of ferric hydrates by many different analysts, and from a great range of localities, give an amount of water which correspond to one or the other of these last two hydrates; but as these contain also either organic matter, phosphoric acid, or silica in the combined state, it is impossible, without further investigation, to know to what hydrate to refer them.

The artificial ferric hydrate precipitated by ammonia from ferric chlorid varies in composition according to the method of

* Rammelsberg Mineralchemie, 150. † Journ. Chem. Society, II, iii, 214.

treatment. Schaffner obtained a hydrate with 1 atom, Gmelin with 2 atoms, and Wittstein with 3 atoms of water; this last kept for some time under water became crystalline and was converted into a hydrate with $1\frac{1}{2}$ atoms of water. Recent investigations by E. Davies* show that the ordinary precipitated ferric hydrate loses water on being boiled in water; in one case the amount of water was reduced to 3·52 per cent. Similar experiments conducted in this laboratory by Mr. Rodman showed that by continued boiling in water the amount of water remaining in the hydrate could be reduced even to 2 per cent. These facts, as Mr. Davies suggests, explain in a very satisfactory manner the association of the different ferric hydrates in nature and do not necessarily demand the supposition of great heat to account for the large beds of anhydrous hematite found in different parts of the world.

Sheffield Laboratory, February, 1867.

Art. XXIII.—*On a new Test for Hyposulphites;* by M. Carey Lea.

In an examination of the platinum metals which I published some time back in this Journal, I described a very delicate test for ruthenium, by which the faintest traces of that metal could be detected through the agency of hyposulphite of soda. Recently, having occasion to test for the last-named substance, it occurred to me as probable that ruthenium might be rendered available for that purpose. This I found to be the case, and that the reaction exhibited considerable delicacy. It is true that ruthenium is at present a very rare metal, and not within the reach of all who might wish to use it, but the changes from rarity to more or less abundance are now so common and sudden that present scarcity is no reason for ignoring any useful reagent.

When a solution of ruthenium is rendered alkaline by ammonia and boiled with hyposulphite of soda, it gradually assumes a rose color which passes into a rich carmine; with strong solution the color is so intense as to be almost black. When diluted the shade is magnificent, rivalling the aniline red in richness.

I have already stated within what limits ruthenium can be detected by hyposulphite of soda. I now subjoin the limits observed with respect to hyposulphite of soda.

A solution containing one four-thousandth of hyposulphite, gave a clear rose red.

* Journ. Chem. Society, II, iv, 69.

One containing one twelve-thousandth gave a well marked pink liquid.

One containing one twenty-five-thousandth gave a salmon color.

The experiment was not carried further because the salmon color in the last-mentioned trial showed that the test had then reached its practical limit. I do not doubt that even with one hundred thousandth a coloration could be obtained, but it would not have the specific distinctness given by the carmine and rose shade previously described.

A few words remain to be said as to the best mode of applying this test.

I have recognized in solutions of sesquioxyd of ruthenium a strong tendency to decompose by dilution: dilute solutions have a strong tendency to gradually deposit their ruthenium as oxyd. And even before the slightest sign of a precipitate appears, in fact immediately upon dilution, solutions show a tendency to change their reactions. So that I find it invariably better on diluting the ruthenium solution for use in testing, to boil it (as I have elsewhere pointed out in speaking of the dilution of ruthenium) with a few drops of hydrochloric acid, and this even although the solution is to be immediately afterward rendered alkaline by ammonia. To ascertain with certainty that this improved the delicacy of the reaction, I made comparative experiments on two portions of the same ruthenium solution, and found that the coloration by hyposulphite was at least three times stronger in the case of the portion that had been boiled with HCl than with that that had not.

As ammonia was thereafter immediately added, it might appear that the function of the hydrochloric acid was to form hydrochlorate of ammonia. But it was found by experiment that the addition of sal-ammoniac in no way aided the reaction.

The addition of ammonia to a hot solution of sesquichlorid of ruthenium immediately darkens it to a blackish olive color, which, according to the dilution and the light that falls on it, is of a reddish or a greenish shade. By standing, the ruthenium is precipitated as oxyd. As this condition is the necessary preliminary (as before explained) to the production of the characteristic carmine reaction, it is not a little singular that the delicacy of that reaction should be so greatly enhanced by taking steps to strengthen the combination with excess of acid and boiling, immediately before the affinities are to be loosened by ammonia.

In using this reaction for the detection of small quantities of hyposulphite, it is useful to remark that it succeeds best when very little ruthenium is present. After the ruthenium solution

has been boiled with acid and supersaturated with ammonia, and the liquid to be tested for hyposulphite added, the mixed solution should have so little ruthenium in it as to exhibit only a very pale transparent olive coloration—should in fact be *almost* without color. Otherwise if the hyposulphite is present in mere traces, we get a salmon or flame color instead of the pure carmine.

ART. XXIV.—*Contributions to Chemistry from the Laboratory of the Lawrence Scientific School. No. 4.—On a new mineral from Rockport, Mass.;* by W. J. KNOWLTON.

IN the March number of this Journal for the present year, Prof. J. P. Cooke has described as malacone a mineral discovered by myself at Rockport, Mass., where it occurs in the granite in veins of massive quartz and feldspar. Prof. Cooke's analysis was made, as he states, upon a small quantity of material and he speaks of it as "imperfect"; he found

Silica,	27·90
Zirconia,	66·93
Sesquioxyd of iron, with trace of manganese,	2·57
Water,	2·19
	99·59

which results, if correct, would unquestionably identify the mineral with malacone. I have repeatedly analyzed this mineral, and my results differ, as will be seen, so much from those of Prof. Cooke, and from the analyses of malacone hitherto published, that I am disposed to consider the mineral as a new species. If this conclusion be admitted, I propose for it the name of *Cyrtolite*, (from κυρτος, *curved*,) in allusion to the very marked curvature of the terminal faces which is observed in the great majority of specimens. The mineralogical characters of cyrtolite have been already described by Prof. Cooke. It is almost always found imbedded in massive feldspar, sometimes in large aggregates of crystals, sometimes in single crystals which are often quite perfect. Fine single crystals are found at various places on the sea-shore where the veins have been exposed by the action of the water. The luster of the crystals is often brilliant, but fracture exhibits a dull brownish-red color. In three determinations of the specific gravity of cyrtolite by Rose's method, I found 3·850, 3·856 and 3·970; the last determination being made upon a specimen from a somewhat different locality, and taken from the surface rock near the shore.

Before the blowpipe cyrtolite glows brilliantly, and is but slightly altered in color. Its powder dissolves rather easily in

borax, giving a distinct reaction for iron. With microcosmic salt it dissolves partially, leaving a white siliceous skeleton. Prof. Cooke states that the mineral is easily and completely resolved by fusion with alkaline carbonates. I have not obtained the same results, but have on the contrary found it very difficult to decompose it completely in this manner; even fusion for several hours with four times the weight of a mixture of carbonate of potash and carbonate of soda failing to produce a perfect resolution. Four consecutive fusions with the alkaline mixture gave but little better results. In another analysis, after fusing for three hours with the alkaline mixture, treatment of the fused mass as an ordinary silicate with chlorhydric acid, and fusion of the silica obtained a second time, there remained 2·20 per cent of earth which could not be further purified by treatment with fluorid of ammonium and sulphuric acid.

When heated with sulphuric acid in a closed tube for two or three hours to a temperature of 210° C., about 33 per cent of undissolved matter remained. On diluting, filtering and boiling the filtrate, from 8 to 13 per cent were precipitated in different experiments, according to the quantity of free sulphuric acid in the solution. When fused with bisulphate of ammonium the mineral is completely decomposed, but it is difficult to avoid loss by spattering. Bisulphate of potash also completely resolves the mineral by fusion, but forms with the zirconia the well known double sulphate which dissolves with much difficulty; bisulphate of soda would doubtless be preferable, but I have not employed it in quantitative analyses. The mineral is more readily resolved by fusion with fluorid of ammonium and subsequent treatment with sulphuric acid. The decomposition is perfect, but of course the silica must be estimated by loss. In four analyses I obtained the following results:

	No. 1.	No. 2.	No. 3.	No. 4.
Silica,	26·29	26·37*	26·48*	26·18
Zirconia,	61·33	61·00	60·00	64·60†
Cerium metals,	2·24	1·80	2·19	1·40
Iron, FeO,	3·65	3·63	3·60	....
Uranium, Ur_2O_3,	....	1·94	2·83	1·40
Tin, with trace CuO,	·35	·70	·35	·41
Water,	4·58	4·55	4·55	4·58
Trace manganese and magnesia,	....	....	....	....
Trace of fluorine,	....	....	....	....
	98·44	100·00	100·00	98·97

In these analyses the water was determined by heating the

* Silica estimated by difference.

† In this analysis the zirconium and iron were not separated.

mineral in a platinum tube in a current of carbonic acid. The silica was estimated in the first analysis by fusion with bisulphate of ammonia, and in the last by fusion with the alkaline carbonates and subsequent treatment with fluorid of ammonium and sulphuric acid. In the second and third analyses, it was determined by loss. Tin and copper were precipitated by sulphydric acid gas. After oxydizing the iron, the iron and zirconia were precipitated together from the nearly neutral solution by acetate of soda. The iron was then separated from the zirconia by Deville's method for the separation of iron and alumina.

In the filtrate from the iron and zirconia, the cerium metals were precipitated by oxalic acid, and the uranium by ammonia. It is not easy to determine in what state of oxydation the iron and uranium exist in the mineral. I have taken the iron perhaps arbitrarily as protoxyd and the uranium as sesquioxyd. In the second and third analyses the uranium was not perfectly separated from zirconia.

It scarcely admits of a doubt that the zirconia in cyrtolite is associated with another and similar oxyd—perhaps titanic acid. When the zirconia is strongly heated in a platinum tube in a current of hydrogen gas the earth assumes a bluish color resembling that seen in niobic and titanic acids when similarly treated. The color disappears on heating the blue mass in the air. If we add to an acid solution of zirconia from cyrtolite—a solution of the earth in fluohydric acid is best—sodium amalgam, magnesium or zinc, a purple or dull violet color is soon observed, sometimes with a precipitate of the same color. In the absence of any method of separating zirconia from titanic acid, &c., quantitatively, I must leave the precise constitution of the metallic acids in cyrtolite undetermined. I am very far from supposing that my analyses of the mineral leave nothing to be wished, but in the absence of good and thoroughly tested methods of analysis, I have done all in my power to obtain correct results.*

Cambridge, June 29th, 1867.

ART. XXV.—*On the subdivisions of the Cretaceous rocks of California;* by WM. M. GABB.

SINCE the publication of the first volume of the California Reports on Paleontology, there have appeared several rather severe, and not altogether good natured criticisms. These have culminated in the publication by the Smithsonian Institution of

* I may be permitted to mention in this connection that I have found *cæsium* in the cryophyllite from Rockport, described by Prof. Cooke. The alkali is easily detected by the spectroscope in the alums obtained from the mineral, but its quantity is very small—much less apparently than that of rubidium.—W. J. K.

a pamphlet purporting to be a check list of Eocene fossils, prepared by one of our oldest Paleontologists. So eminent an authority and the endorsement of so respectable an institution require that I should say something in vindication of the position I have taken, and give to the scientific world the grounds on which I base my deductions.

The rocks of California, included by the Geological Survey under the general head of Cretaceous, can be easily separated into two well-marked divisions. Our acquaintance with them has not yet been sufficiently detailed to attempt a further separation into sub-groups, though, in the older members, that can doubtless be done hereafter. This older group is without doubt the equivalent of the No. 5 and the upper part, if not the whole of No. 4 of Meek and Hayden's Nebraska section. There may be, and in fact probably are, older members of the Cretaceous formation represented in California, but our information is, as yet, too limited to make the assertion positively. In the northern part of the state, where these rocks have been least studied, isolated specimens have been obtained with a decidedly "Neocomien" aspect. The more recent member, always conformable with the lower, and connected with it by a series of strata not very fossiliferous, appears to be the American representative of the Maestricht beds, the 'Danien' of the French authors. The position of the older group is universally conceded, and it only rests with me to establish that this newer group is without doubt Cretaceous and not Eocene as Mr. Conrad originally asserted and still maintains.

It has many points in common with the Maestricht beds of Europe. It contains but a single species, so far as known, of the complex-chambered group of Cephalopods. A solitary ammonite, represented by half a dozen specimens, has been found by myself, in place, even to the very top of the formation.

The rocks which I included in my Division B, are found in and more particularly along the eastern face of the Coast Ranges over an extent of upwards of four hundred miles. They are in many places metamorphosed, but are in a number of localities highly fossiliferous. The principal localities from which fossils have been collected are—the vicinity of Fort Tejon, New Idria, near Griswold's on the road between New Idria and San Juan, Clayton at the Monte Diablo coal mines, Martinez, San Diego and on one of the forks of Eel river near Round Valley, Mendocino county. At Clayton and Martinez they are connected with Division A by a regular succession of intermediate beds but containing very few fossils. Near the village of Lower Lake, Lake county, these intermediate beds are again developed and are then highly fossiliferous.

In the California Cretaceous rocks we have already recog-

nized and described 280 species, besides about fifty species not yet described but of which we have sufficient material for publication, and about 30 or 40 species, the existence of which is indicated by fragments too imperfect for description. Of these species 107 are found in Division B. Of these 107, 84 are, so far as known, peculiar to this group, and 16 are found in common in undoubted members of both divisions, while 7 more are found in the intermediate beds associated with a nearly equal number of representatives of the lower group. Thus the two groups are connected by a passage of nearly one-fifth of all the species found in the upper member.

The following analysis will prove the above statements more clearly.

Of the 107 species of fossils found in Division B, 44 are found at Clayton, 67 at Tejon, 54 at Martinez, 22 at San Diego, 18 near Griswold's, and 7 near New Idria. It is not intended to be understood that these are all of the species found at these localities; but that, up to the present time, these are all that have been identified or described. Future work will undoubtedly change the above figures.

Of the species found at the above localities, 50 are peculiar to one or another locality; 29 are found at two localities only, 14 at three localities, and 14 at four localities or more.

Taking the three typical localities, Martinez, Clayton and Tejon, 21 species are common to Martinez and Clayton, 30 to Martinez and Tejon, 25 to Clayton and Tejon, and 20 are found at all three localities.

As I have stated above, 16 species found in the upper member also extend into the older group, Division A. In addition to this, at the locality near Lower Lake Village, Lake county, besides several species encountered for the first time, I found 15 species in the same bed, within a superficial area of two feet. Of these, 3 were previously known to be common to the upper and lower division. Besides these 3, 7 of them were common to this locality, and localities of division B, and the remaining 5 were, before this discovery, considered peculiar to the lower member. One of these 5 is found in the Mississippi Valley, in the "Ripley Group," and another belongs to a peculiarly Cretaceous genus.

As to the species found at the several typical localities, independent of each other, and which would serve to show their individual relations to the older formation without corroborative evidence, Clayton has 10 species in common with Division A, Tejon has 7, and Martinez 11. With the Lower Lake bed, Clayton has 5 species in common, Tejon 5, and Martinez 6.

In glancing over Mr. Conrad's "check list" I find that out of the 107 species found in his "Older Eocene of California," he

has only included 74 in his enumeration. He has omitted *Callianassa Stimpsonii*, Ammonites n. s., *Nautilus Texanus*, *Cylichna costata*, *Mactra Ashburnerii*, *Cucullæa Matthewsonii*, *Nucula truncata* and *Leda protexta;* eight species, which I mentioned in the Journal of Conchology (vol. ii, p. 88), as being found in common in the two members of the California Cretaceous, stating distinctly the localities in which they have been found. At the same time he includes five other species, from the same list, in his Eocene catalogue. Whether this be carelessness, or an unfair avoidance of a difficulty, I leave to others to decide. It is far easier to ignore such a difficulty than it is to explain it away.

In regard to the distribution of the genera and species in this and the associated rocks: all of the species are peculiar to this group, or to this and *underlying* rocks; *not one* has been found associated either with living forms, or with species known to occur in the recognized Tertiaries of California. Five of the genera are peculiar to the Secondary. An Ammonite ranges entirely through the group to the top of the highest fossiliferous strata. The genera *Perissolax*, *Gyrodes*, *Margaritella*, and the sub-genus *Anchura*, of the genus *Aporrhais*, are all recognized as strictly characteristic of the Cretaceous; so much so, that the presence of a single undoubted representative of either of these genera would be strong presumptive evidence of the Cretaceous age of any rocks in which it might be found. On the other hand, the presence of such genera as those in the list given below, would point to a very modern era in the Cretaceous, to say the least.

It must be borne in mind that we have much to learn yet in paleontology, especially in the matter of the vertical range of genera. Every year we find genera, nay, whole families, extending themselves beyond what had been fixed by previous authors as their limits. A few years ago, the presence of mammalian remains was considered characteristic of the Tertiaries. Now we know of Marsupials in the Trias, and who dare say that we may not find mammals in Paleozoic rocks? I therefore maintain, that though we have here such genera as Aturia, Typhis, Cordiera, Pseudoliva, Nassa, Mitra, Ficus, Morio, Cerithiopsis, Cypræa, and Galerus, still, the only inference that can be drawn is, that the group is on or near the verge of the formation, a sort of prophetic member, presaging by some of its genera the formations to come, but indissolubly bound by specific ties with the eras preceding.

ART. XXVI.—*On a new apparatus for technical analysis of Petroleum and kindred substances;* by S. F. PECKHAM.

IN the Chemical News for August 31st, 1866, I noticed a paper in which was described a process with apparatus, for the assay of coals and other substances yielding illuminating and paraffin oils.* After stating the fact, that no process had hitherto been described by which technical analyses of bituminous and pyro-bituminous substances could be made to yield analogous and satisfactory results, the author proceeds to describe what I should suppose to be a very valuable process for the primary distillation in the technical analysis of coals and shales. I do not repeat the description here, as it would require considerable space, and it can only be applied to the treatment of solid substances, which do not melt at a temperature below that required for their distillation. As the original paper is easy of access, I would recommend its perusal to all who wish to make technical analyses of either coals or shales. The apparatus is simple and inexpensive, and I am aware of no reason why the results furnished by it should not prove highly satisfactory, especially as its operation bears a striking resemblance to the most improved processes of manufacture on the large scale.

But beyond the primary distillation of the coal or shale, I do not consider that our author has added anything to processes long in use. When he arrives at the second distillation, or that which corresponds to the primary distillation of petroleum, he is forced to return to the old process of fractional distillation from a common tubulated glass retort. This process is not only very unsatisfactory in its results, but it is quite expensive, and is attended with considerable danger from fire. It is unsatisfactory, because the separation of fluids of different densities and different boiling points, is much less complete than by Warren's process, for any temperature below the boiling point of mercury; in fact, for any temperature necessary to ensure the complete separation of the light oils usually called naphtha, and the "photogen" or illuminating oil.† It is expensive, for the reason that if the distillation is conducted to dryness the retort is sacrificed, as it is rarely possible to remove the coke with safety. It is attended with danger from fire, because the best retorts are liable to fracture from the high heat to which they are exposed, even when the greatest care is exercised in conducting the operation.

* On the Assay of Coal, etc., for Crude Paraffin Oil, and of Crude Oil and Petroleum for Spirit, Photogens, Lubricating oil and Paraffin, by John Attfield, Ph.D., F.C.S., Director of the Laboratory of the Pharmaceutical Society of Great Britain. Chem. News, vol. xiv, p. 98.

† For details of this process, see Mem. American Academy, N. S., vol. ix, Chem. News, vol. xii, p. 85.

I was about to commence a technical examination of several specimens of California petroleum, when the above mentioned paper arrested my attention, and I was unpleasantly conscious when I had finished its perusal that in respect to apparatus for this department of research my want was just as far from being supplied as it was six years since, when I commenced the study of petroleums. I had but a small quantity of each specimen, and besides subjecting them simply to fractional distillation, I wished to test them by Young's process of distillation under pressure. To conduct the latter process in glass was an impossibility.

To answer my purpose therefore, my apparatus must fulfil the following conditions. It should be capable of working not more than one and one-half liters, and admit of being heated by an ordinary gas furnace. The joints should sustain a pressure of forty pounds per square inch, and it should be so constructed as to admit of the ready extraction of the coke. I could find no description of any such apparatus, but after numerous failures and corrections, in an apparatus of my own invention I found my want so well and fully supplied, that I am led to offer a description, for the benefit of those who, like myself, have felt the need of such an instrument.

Upon each extremity of a piece of a wrought iron gas-pipe, three inches in diameter and twenty inches in length, a cap is securely screwed. The caps should be heated nearly to redness and screwed on to the cold pipe in order that by their contraction they may be more firmly secured. The pipe is then put in a lathe and the caps turned off in such a manner as to leave a band upon each end of the pipe, about three-fourths of an inch in width, and two circular discs of iron, each about four inches in diameter, and one-fourth of an inch in thickness, having a projection upon one of their surfaces to which a wrench may be applied. The edges of each extremity of the pipe with the bands are now carefully turned off, presenting smooth surfaces slightly beveled inwardly. The plane surface of each of the discs is then so turned off upon its circumference, that it will exactly fit the beveled edge of the pipe. This completes the retort.

A stout parallelogram is then made half an inch longer and wider than the retort, one of the shorter sides of which should contain in the middle a stout set-screw, and the other an orifice made to fit the projection upon the disc. This may be called the frame.

Two holes are then drilled a short distance from either extremity of the retort, and in a line parallel to the axis of the retort. One of these should admit a half inch, and the other an inch gas-pipe. With this arrangement the retort may be used either for pressure distillation, or for distillation by the ordinary process. It also admits of being connected with an apparatus

for furnishing superheated steam or carbonic acid gas, either of which are sometimes used to assist the distillation of hydrocarbons. Both the goose-neck and valve should be connected with the retort by a short piece of gas-pipe and a brass "union" or coupling, as the difference in the expansion of brass and iron would cause a joint of the two metals to leak very badly when subjected to a high temperature. The goose-neck may be made of the ordinary form, tapering from one inch to one-quarter inch, and about ten inches in length. The material should be copper, brazed. The valve will be described hereafter.

In order to use the retort, one of the discs is luted with a very thin paste of plaster of Paris and firmly pressed into its seat. The retort is then slipped into the frame and left a moment for the luting to set, the open end being uppermost. The oil is next poured in and the other disc luted into its seat, the frame adjusted and the set-screw firmly set up, so as to securely fasten both discs in their places. The goose-neck or valve is then adjusted, and the connections made with the worm and receiver. It will be observed that all the expansion that takes place in this retort only brings the different portions of the apparatus more firmly together, instead of causing them to crack apart and leak with every slight variation of temperature, as is usually the case. With this arrangement I was able to distill fifteen hundred cubic centimeters of petroleum to dryness, the last portions coming over at a red heat. The distillation was commenced with two ordinary Bunsen's gas lamps, increased as required to four, and toward the end of the operation to six—the latter number being sufficient to bring the side of the retort in contact with the flame to a bright cherry-red heat.

Any one who has attempted the distillation of small quantities of petroleum in either iron or copper stills, or retorts of whatever form, imbedded in coal fires or suspended over them, must be aware of the difficulty of so regulating the fire as to secure a constantly increasing heat from the beginning to the end of the operation. No such difficulty is experienced with this apparatus. In it the lightest oils may be distilled by means of a sand-bath, and the heaviest by applying the flame of a sufficient number of lamps directly to the retort. The joints of this apparatus when luted with the smallest possible quantity of finely pulverized calcined sulphate of lime, admit of the least loss by leakage of any metallic retort that I have ever used. With the exercise of proper care the amount of distillate from California petroleum averaged above ninety per cent by measure, and with a pressure of thirty pounds per square inch the average was eighty-seven and one-half per cent. In the latter instance the loss was increased by the formation of gas and vapors that passed through the worm uncondensed at 8° C. The largest

amount of distillate that I have seen recorded, as yielded by any material of undoubted natural origin, is ninety-five and one-half per cent, by measure.* The distillation of which this was the product was performed wholly in glass, without pressure, the crude material being a California petroleum of medium density, yielding no permanent gases and no naphtha. In this case the loss may be estimated at zero. I think it will be readily conceded, that any apparatus which admits of the ready extraction of the coke, and at the same time yields an average of ninety-two and one-half per cent of distillate, furnishes results far more satisfactory than any hitherto in use for operating upon so small a quantity as fifteen hundred cubic centimeters.

A thermometer may be inserted in the smaller orifice, for noting the temperature at which light oils distill. A piece of gas-pipe of the requisite size and about two inches in length may be used for making the connection, the thermometer being luted into one end of it. When but one of the openings in the retort is in use, the other may be closed with an iron plug.

In making my experiments upon Young's process of distillation under pressure, I experienced much difficulty in contriving an apparatus that would enable me to register the amount of pressure, and at the same time prevent any loss of vapor. I first attempted to register the pressure by means of a U tube, the arms of which were of unequal length. The tube was filled with mercury to a level with the shorter arm and the long arm sealed with a column of air above the mercury. The pressure was indicated by the rise of mercury in the longer arm and consequent compression of the air, the shorter arm being in communication with the retort. The escape was badly regulated by an ordinary stop-cock. The very unequal expansion of glass and iron prevented me from making a tight joint between the retort and U tube.

I next tried a small valve constructed like an ordinary safety valve. I found it impossible with this valve to prevent a large amount of loss from escape of vapor around the spindle.

I next tried a loaded valve, the load of which was placed directly upon the spindle, the whole contained in a chamber resembling a miniature steam-chest, from which the vapors could only escape into the worm. It was found upon trial with the safety-valve that an orifice three-eighths of an inch in diameter was too large in proportion to the size of the retort, the vapors escaping in too large volume to admit of a continued flow from the worm. The vapor escaped in intermittent puffs, thereby causing an undulatory movement from the requisite amount of pressure to no pressure at all. As a consequence, the results

* Report of C. M. Warren, Esq., contained in an article on Petroleum in California, by Prof. B. Silliman, National Intelligencer, Feb. 7th, 1866.

rendered were very imperfect. To obviate this difficulty, I made the orifice beneath the valve only one-sixteenth of an inch in diameter, the surface of the orifice being to that of the retort as one to sixty thousand. This arrangement enabled me to secure a constant flow of vapor from the retort, to maintain a constant pressure, and to preserve a constant degree of temperature. I found by computation that a pressure of two ounces avoirdupois upon an orifice one-sixteenth of an inch in diameter was equivalent to a pressure of forty pounds to the square inch, yet when I placed a weight of two ounces upon the spindle, which of itself weighed half an ounce, the steam gauge registered only ten pounds, and the oils passed through it unchanged in density. Although I employed one of the most skillful workers of brass in this city to grind the valve, I am satisfied that the fault was in the mechanical execution of the work, and that the bracing of the valve was upon the side of the cone instead of at its apex, leaving a minute cavity beneath the valve. This fault could only be remedied by increased pressure. The chamber being too small to admit of placing the requisite weight upon the spindle, I made use of a spiral spring, the force of which was adjusted by an ordinary steam-gauge. By this means I was enabled to obtain the required pressure and to estimate its amount, with but one source of error, viz., the diminution in the elasticity of the spring incident to the high temperature of the vapors of the oil. I am convinced that the amount of this diminution is considerable; I have estimated it at one-fourth. The original elasticity returns, however, as soon as the spring is cold.

The following is a description of the valve as finally arranged. A piece of wrought iron gas-pipe one inch in diameter and three inches in length is bored out true, and an orifice drilled in its side one and one-fourth inches from the upper end, into which is brazed a piece of quarter inch gas-pipe about three inches in length. Both ends are now turned off and threads cut upon them, to which are carefully fitted strong brass caps. The upper cap should be about three-quarters of an inch in thickness, perforated two-thirds through from the inside with an eighth-inch drill, the orifice to serve as a guide to the upper end of the spindle. There should be a nipple three-fourths of an inch in length upon the lower cap, to connect it with the retort. The cap should be about one-half an inch in thickness, and with the nipple, should be perforated with a sixteenth inch drill. The seat of the valve should be excavated in the inside of the lower cap. A diaphragm should be placed within the iron tube, one inch from its lower end to serve as a guide for the spindle, through the center of which the spindle should pass, while around it should be numerous small openings to allow for the free passage of the vapor. The valve itself should be turned upon the end of a spindle three-sixteenths of an inch in diameter,

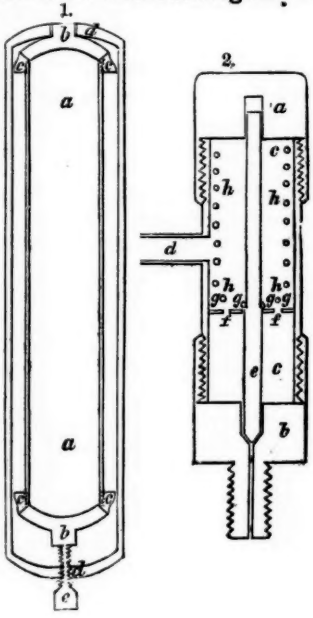
and carefully ground into its seat. The length of the spindle should be one-fourth of an inch less than the distance from the seat of the valve to the bottom of the orifice upon the inside of the upper cap, when both caps are in position. This allows the spindle to lift well, with sufficient room for the passage of the vapors. The diameter of the spindle should be reduced to one-eighth inch above the diaphragm. A spiral spring, of a diameter nearly equal to the interior of the pipe, made of brass wire about one-sixteenth of an inch in thickness, is so adjusted that the valve would be raised against the elastic force of the spring. This is effected by gradually reducing the diameter of the coils of the lower end of the spring to one-eighth inch, when it will just rest upon the shoulder upon the spindle. The upper coil of the spring should just touch the inside of the upper cap, when it is firmly screwed up. It will thus be seen that a force sufficient to cause the spring to contract one quarter of an inch is equal to a direct pressure upon the valve of two ounces. This pressure may be regulated by an ordinary steam gauge, the force depending for the same length of spring and size of wire upon the *number* of coils employed.

With this apparatus and the one described by Mr. Attfield, small quantities of every variety of bituminous and pyro-bituminous substance, may be subjected to treatment analogous to the most improved processes now in use upon the large scale. The results are reliable and admit of ready comparison. The cost of the retort with goose-neck and valve, made by the most skillful workmen, is about twenty-five dollars.

The annexed diagrams give a section of both the valve and retort.

Fig. 1 represents a horizontal section of the retort, one-fourth the size; in which *a a* is the gas-pipe; *b b* are the discs; *c c c c* are the bands left when the caps are turned off; *d d* is the frame and *e* the set-screw.

Fig. 2 represents a vertical section of the valve, of full size, in which *a* represents the upper cap, *b* the lower cap, *c c* the gas-pipe, *d* the escape pipe, *e* the spindle, *f f* openings in the same for passage of vapors, *g g g g* the diaphragm, and *h h h h* the spiral spring.



Providence, R. I., April 30th, 1866.

ART. XXVII.—*Notes on the Grass Valley Gold-mining District;* by Prof. B. SILLIMAN.

GRASS VALLEY DISTRICT has obtained a well-earned celebrity as the most prosperous of all the gold-quartz mining districts in California. Quartz mining was begun here as early as 1850, and has been continued with, on the whole, a steadily increasing success, to the present time.

It is difficult to obtain exact statistics of the total product of the Grass Valley quartz mines, but it is believed by those best able to form a trustworthy opinion on this subject, that the product in 1866 was probably not less than $2,000,000, while for the whole period from 1851—say fourteen years—it was probably in excess of $23,000,000.

Wm. Ashburner, Esq., in his remarks on the gold mining interests of California, in J. Ross Brown's Report on the Resources of the States and Territories west of the Rocky Mountains, speaks of the Grass Valley region (page 46) thus:

When we consider the richness of the veins, the length of time some of the mines have been worked, and the amount of gold annually produced, the most important quartz mining region of California is, without any doubt, that of Grass Valley, in Nevada county. Here mines have been worked uninterruptedly since 1851. It is true there have been periods when the interest was more than usually depressed, and several of the mines, which are now regarded as among the best, were thought to be exhausted and were abandoned for the time being, but in many instances where work was resumed new bodies of gold-bearing quartz were opened up, which proved rich and valuable. The veins in this district, and particularly those which have been most productive, are noted for their narrowness, as well as for the richness of the quartz. They are encased in a hard metamorphic rock, and the expenses of mining are, as a general thing, higher here than anywhere else in California, amounting as they do in some instances, to from $20 to $26 per ton. Within the last fourteen years the total production from the quartz mines of Grass Valley District has been not far from $23,000,000. The most prolific vein has been that situated upon Massachusetts and Gold Hills, which alone has produced more than $7,000,000 worth of gold during this time, from a lode which will average only a foot or fourteen inches in width.

The gold bearing rocks at this place are mostly highly metamorphic schists or sandstones passing into diorite or greenstone syenite. These greenstones seemingly crystalline, are probably only highly altered sedimentary rocks, containing a large amount of protoxyd of iron with sulphuret of iron. In some parts of

the district, slaty rocks occur, more or less talcose or chloritic in character; masses of serpentine also abound, forming at times one wall of the quartz veins. This serpentine is probably metamorphic of the magnesian rocks last named. The red soil, seen almost everywhere in the Grass Valley district, has its origin in the peroxydation of the iron contained in the greenstones and diorites, and set at liberty by their decomposition.

The line of contact between the gold-bearing and metamorphic rocks of Grass Valley, and the granites of the Sierra Nevada is met on the road to the town of Nevada, about half a mile before coming to Deer creek. The talcose and chloritic slates are seen to the north, in the direction of the Peck lode, and in the slate districts of Deer creek.

The dip and strike of the rocks in the Grass Valley region is seen to vary greatly in different parts of the district. Following the course of Wolf creek, a tributary of Bear river, it will be observed that the valley of this stream—which is Grass Valley—as well as of its principal branches, follows in the main the line or strike of the rocks. In the absence of an accurate map of the region, it may not be easy to make this statement evident. But all who are familiar with the chief mines of this district, will recall the fact, that the course of the veins in the Forest Springs location, at the southern extremity of the district, is nearly north and south—N. about 20° E.—with a very flat dip to the east, while at the Eureka mine, on Eureka hill, about four miles to the northward, the course of the vein is nearly east and west with a dip to the south of about seventy-eight degrees. Again, commencing at North Gold Hill and following the course of the famous vein which bears the names of Gold Hill, Massachusetts Hill and New York Hill, we find the veins conforming essentially to the southerly course of the stream with an easterly dip. The North Star, on Weimar Hill, has likewise the same general direction of dip. Near Miller's ravine, at El Dorado mill, Wolf creek makes a sudden bend to the left, or east, leaving the Lone Jack, Illinois, Wisconsin and Allison Ranch mines to the west. All these last named mines are found to possess a westerly dip, showing the existence of a synclinal axis running between the base of New York Hill and the mines having westerly dips last named, along which probably the veins will, if explored in depth, be found "in basin." The dip at Lone Jack is about 30° W., at Allison Ranch it is about 45° W. Just below the Allison Ranch mine, Wolf creek again makes a sharp turn to the left, nearly at a right angle, and then resumes its former course with the same abruptness. A mile lower down, where it strikes the Forest Springs locations, we find the Norambagua inclosed in syenitic rocks, dipping at a very low angle to the east, a dip seen also at still less angle in the Shamrock,

yet farther south. There is probably a saddle or anticlinal axis below the Allison Ranch mine, due to the elevation of the syenitic mass, which, it seems probable, sets in at the sharp bend in the stream, before alluded to, and where the ravine trail joins it. The stream probably runs pretty nearly in the basin of the synclinal.

The rocks on the east side of Wolf creek, and above Forest Springs locations, dip westerly. Such is the case at Kate Hayes, and with the veins on Osborn Hill. The middle branch of the creek sweeps around to the east, forms its junction with the north fork, and the veins explored there near its upper waters, as at Union Hill, the Burdett ground, Murphy vein, Lucky and Cambridge, all dip southwest or south, conformably to the Idaho and Eureka, and at a pretty high angle. The Eureka vein going west, faults in the Whiting ground, and having previously become almost vertical has, west of the fault, a *northerly* dip at a high angle. At the Coe ground, this northerly dip is also found at an angle of about 50°. At Cincinnati Hill the vein dips southerly, in a direction exactly opposite to that of the North Star, there being a valley between the two, and a saddle or anticlinal between Cincinnati and Massachusetts Hills.

These facts, which, by a more detailed statement, could be easily multiplied, seem to warrant the conclusion that the course and dip of the Grass Valley vein is especially conformable to that of the rocks, and that the streams have, in general, excavated their valleys in a like conformable manner.

The quartz veins of Grass Valley District are not generally large. Two feet is probably a full average thickness, while some of the most productive, and those which have given, from the first, a high reputation to this region, have not averaged over a foot or possibly eighteen inches in thickness. There are some exceedingly rich veins which will hardly average four inches in thickness, and which have yet been worked at a profit, while at the same time there are veins like the Eureka which have averaged three feet in thickness, and the Union Hill vein over four feet. The Grass Valley veins are often, perhaps usually, imbedded in the inclosing rocks, with seldom a fluccan or clay selvage or parting, although this is sometimes found on one or both walls. The walls of the fissures and the contact faces of the veins are often seen to be beautifully polished and striated.

The veins are, as a rule, highly mineralized and crystalline, and afford the most unmistakable evidence of an origin from *solution* in water, and not the least evidence of an igneous origin. Chalcedonic cavities and agatized structure are very conspicuous features in many of the best characterized and most productive of the gold-bearing veins of this district. These indisputa-

ble evidences of an aqueous origin are seen in Massachusetts Hill, Ophir Hill, Allison Ranch, Kate Hayes and Eureka.

The metallic contents of Grass Valley veins vary extremely, some carry but very little or no visible gold or sulphurets, although the amount of gold is found in working in mill to be satisfactory, and the sulphurets appear on concentrating the sands from crushing. This is the case in the Lucky and Cambridge mines, for example. But in most cases, the veins of this district abound in sulphurets, chiefly of iron, copper and lead, the sulphuretted contents varying greatly in the same vein; zinc and arsenic are found also, but more rarely. The most noted example of arsenical sulphurets are in the Norambagua and on Heuston Hill; lead abounds in the Union Hill lodes (as galena,) and the same metal is found associated with the yellow copper in parts of the Eureka mine. The gold when visible is very commonly seen to be associated with the sulphurets—this was particularly the case in Massachusetts Hill; while in Rocky Bar and Scadden Flat, on the same vein, the gold is found sometimes in beautiful crystallized masses, binding together the quartz and almost destitute of sulphurets. Mr. William Watt informs me that in working some seventy thousand tons of rock from Massachusetts Hill vein, the average yield of gold was about $80; but at times this vein was almost barren, while again the gold was found in it so abundantly, especially where it was thin, that it had to be cut out with chisels. It is matter of notoriety that in the Gold Hill vein (continuation of the vein in Massachusetts Hill) portions of the lode were so highly charged with gold that the amount sequestered by the miners in a single year exceeded $50,000. On the other hand, in the Cambridge and Lucky mines, yielding about $35 to $60 of gold to the ton, the precious metal is seldom visible. In the Eureka, where the average yield of gold in 1866 was $50 per ton, it seldom exhibited what may be called a "specimen" of gold.

The structure of the veins in Grass Valley varies, in different portions of the district, especially in respect to the distribution of the pyrites and of portions of the adjacent walls. On Eureka Hill, the veins possess a laminated structure parallel to the walls, enclosing portions of the diorite or talcose rocks, forming closures or joints in which the vein splits easily. On these surfaces of cleavage minute scales of gold may often be detected by close inspection. The sulphurets are also seen to be arranged in bands or lines parallel to the walls. In many other cases, this kind of structure is found to be wholly absent, while the sulphurets and gold appear to follow no regular mode of distribution. In a few mines the sulphurets are arranged very distinctly in bands of zones, parallel to the walls, forming "rib-

bon quartz." This is especially distinct in the Norambagua, where, as before mentioned, the sulphurets are arsenical, and the gold very finely disseminated.

The average amount of gold in the Grass Valley veins is believed to be considerably in excess of what is found in most other portions of California. In Allison Ranch, Massachusetts Hill, Rocky Bar, Ophir Hill, and Eureka, this average has probably reached $50 to the ton. In many other mines it has been considerably less, but on the whole, $30 may not be far from the general average for the whole district; meaning of course, the amount actually saved by milling operations.

The loss of gold is very various, but is probably nearly always greater than owners are willing to confess—if indeed they know, which is doubtful. It is certain, in one well known mine, my own samples of quartz sands, and sulphurets from "pans," assayed respectively $23 and $57 per ton—a result which was later confirmed, quite independently, by the researches of a very competent mining engineer. In other cases, as at Eureka and Norambagua, my own researches show the loss in the tailings to be very small, not exceeding seven dollars to the ton in the latter, and less than that in the former.

The gold in many of the Grass Valley mines is very easily worked, being clean, angular and not very small, hence it is readily entangled in the fiber of blankets, together with a considerable portion of sulphurets, naturally leading to the method most commonly in use in Grass Valley for treatment of the gold ores.

What may properly be called the Grass Valley method of amalgamation consists in the use of heavy stamps, seven hundred or a thousand pounds, crushing usually two tons, sometimes two and a half tons of ore each in twenty-four hours—through screens not exceeding No. 6, rarely so fine. Amalgamating in battery and copper aprons are usually omitted. In some mills, murcurial riffles are placed in front of the discharge, but commonly the whole body of crushed stuff is led at once over blankets, which are washed out every few minutes into tanks where the free gold and sulphurets are allowed to collect preparatory to being passed through the "Attwood amalgamators." These simple machines are designed to bring the gold into thorough contact with mercury contained in little vats sunk in the surface of an inclined table, over which the stuff is fed to the vats in a regulated manner by a stream of water, while iron blades slowly revolve in the vats to cause a mixture of the sands and quicksilver. By this apparatus, at the Eureka mill ninety per cent of all the gold is obtained which is saved from the ore. Beyond the amalgamators, the sands are carried over amalgamated copper sluices, and are put through various ore-

saving processes with a view especially to concentrating the sulphurets. These processes vary much in different mines. In some mills, especially the Ophir, much more elaborate mechanical apparatus has lately been introduced—with what results still remains to be seen. It is certain that if the method of treatment just sketched seems imperfect, (as it undoubtedly is,) it is the method which has hitherto yielded the large returns of gold for which Grass Valley has obtained its well-deserved renown. As the development of the district goes forward, cases will occur of veins containing gold in a state of very fine division, to which other methods of treatment must be applied. Such examples indeed already exist, and the problems which they offer will be met by the use of other systems of amalgamation, or by suitable modifications of the existing system.

The sulphurets occurring in the Grass Valley District are usually rich in gold—some of them remarkably so. In quantity they probably do not on an average amount to over one per cent of the mass of the ores, although in certain mines they are found more abundantly. For a long time there was no better mode known of treating them than the wasteful one of grinding them in pans and amalgamating. In this way rarely was 60 per cent of the gold saved. After many abortive efforts, at length complete success has been met with in the use of Plattner's chlorination process. Mr. Deetken, now connected with the reduction works of the Eureka mine, is entitled to the credit of having overcome the difficulties which formerly prevented the successful use of this process in Grass Valley, a more detailed description of which will be found in our notice of the Eureka mine.

Of the length of the productive portion of quartz veins and the depth at which they commence to become productive, Grass Valley offers some instructive examples.

The North Star vein, on Weimer Hill, has been proved productive on a stretch of about one thousand feet, while the proportion of gold has gradually increased with the depth, from an average of twenty dollars in the upper levels to nearly double that in the lower levels. The limits named are rather those of exploration than the known extent of the productive ore. In the vein on Massachusetts and Gold Hills, on the contrary, the distribution of the "pay" has been found much more capricious, being at times extremely rich, and again with no apparent reason yielding scarcely the cost of milling. The Eureka mine offers the most remarkable example, however, of a steady increase from a non-paying amount of gold near the outcrop to one of uncommon productiveness. An opinion has found advocates, and has been perhaps generally accepted by most writers on the subject of gold-bearing quartz veins, that they were richest near the

surface and in depth became gradually poorer. There is nothing in the nature of the case, as it seems to me, to justify such a generalization, more than there is to sustain an opposite opinion. If we accept facts as a guide, we find in California that the deepest mines, for example, Hayward's Eureka, in Amador, 1,200 feet, North Star, 750 feet on the slope, Princeton, in Mariposa county, 800 feet, Eureka (Grass Valley) 400 feet, Allison Ranch, 525 feet, etc., as a rule have an increasing amount of gold. If the Allison Ranch, the Princeton mine, and some others appear to be exceptions, the answer is, we may reasonably expect the same variations of productiveness in depth which are known to exist in linear extent. The Princeton, after an excellent run of good ore, became suddenly poor, at a depth of over six hundred feet, in 1865; but I am informed by Mr. Hall, the present superintendent, that the good ore came in again in a short distance. Mr. Laur, the French engineer, whose papers on California mines is often quoted, cites the Allison Ranch mine in evidence of the theory of a decreasing amount of gold in depth, but it is in proof that since the date of Mr. Laur's visit (1862-3), this mine has been at work on ores which have yielded over one hundred dollars value, its present suspended activity being due to causes quite unconnected with the intrinsic value of the mine. The rich "chimneys," or productive zones of ore ground, are known to be of various extent in quartz veins, from a few feet to many hundreds of feet, and it is impossible to assign any valid reason why we may not expect the same changes in a vertical direction which we find in a horizontal. As the ore-bearing ground or shoots of ore have in many, if not in most cases, a well determined pitch of the vertical, it is self-evident that a vertical shaft, or incline at right angles to the vein must, in descending, pass out of the rich into poor ground, at certain intervals, and it is perhaps due to ignorance of this fact that miners have abandoned sinking because they found the "pay" suddenly cease in depth, when a short distance more would probably bring them into another zone of good ore. The experience of every gold mining district offers examples in illustration of these remarks. In quartz veins containing a considerable amount of sulphurets, it is evident that the outcroppings should offer much better returns to mining industry than will follow after the line of atmospheric decomposition has been passed, because above this line nature has set free the gold formerly entangled in the sulphurets, leaving it available for the common modes of treatment, with the added advantage often times that the particles of free gold formerly distributed through a considerable section of the vein, are found concentrated in a limited amount of ore. It is easy to reach the conclusion in such cases, that the amount of gold in the vein is less in depth,

after the real average amount is reached, while in fact it is neither greater nor less; but the metal is no longer available by common methods of treatment.

The Eureka mine.—From the date of its location, February 7, 1857, to the close of 1858, the mine proved only a source of expense to its owners, and its history is instructive as suggesting that shallow surface explorations, in gold mining, may be as unsatisfactory as they are known to be in other mining enterprises. So late as 1858, it is said, that five thousand tons of quartz taken above the drain level, or thirty feet from the surface, yielded in mill less than ten dollars per ton in gold, not returning expenses. A shaft sunk to a depth of about fifty feet afforded quartz, however, which yielded about fifteen dollars per ton, and the amount of gold rapidly increased to twenty-eight dollars at one hundred feet. Between the one hundred and two hundred feet levels the average yield was about thirty-seven dollars per ton, and between the two hundred and three hundred feet levels the average has been about fifty dollars per ton, rising to sixty-four dollars in the last four months of 1866.

There are in fact two distinct veins in the Eureka mine, separated from each other by a mass of greenstone or metamorphic sandstone, about twenty-eight or thirty feet in thickness. The smaller of these veins is on the south and has not been explored, but is a well-defined vein at the points where the shaft and cross cuts have exposed it. The greenstone forms the hanging wall of the main vein, and is particularly regular and smooth, in some places beautifully polished. The foot wall consists in some parts of soft serpentine, and when the vein pinches it appears to be from swelling of the foot wall. No other mine in this region has such a structure as the Eureka, so far as I know, and there is very much in the peculiarities here described to favor the highest confidence in the permanence of this great ore channel, both in depth and extent.

It is interesting to analyze a little more in detail the returns of this mine, as illustrating a point already alluded to, viz—its progressive increase of gold with an increase of depth.

From October, 1865, to December 31, 1865, the quantity of quartz crushed was twenty-four hundred and forty-five tons, yielding an average of $33.87 per ton, and costing to mine and reduce $13.51.

From January 1st to June 1st, 1866, the crushing was forty-seven hundred and three tons, averaging $42.68 per ton, at a cost of $12.52 per ton.

From June 1st to September 30, 1866, the amount of quartz crushed was forty-two hundred twenty-seven and three-fourths tons, giving an average yield of $60.33 per ton, at a cost of $15.78 per ton.

For the whole year ending September 30, 1866, the total crushing was eleven thousand three hundred and seventy-five and three-fourths tons, yielding a general average per ton of $47.15, at a mean cost per ton of $13.75.

The net profits for the year ending September 30, 1866, were $368,042.18. The ratio of costs of mining to the gross product was, for the three periods named above, respectively, 40½, 29½ and 26½ per centum. In the mining costs are included all charges for dead work, machinery, etc. The profits of the Eureka mine have, therefore, for the period named, averaged in round numbers from sixty to seventy-four per cent of the gross product of the mine. The earnings are divided every twenty-eight days, making thirteen annual dividends.

The bullion of the Eureka mine is about 850-thousandths fine, worth $17.57 per ounce. This value is, of course, slightly variable, say within five-thousandths.

Art. XXVIII.—*The Action of Sunlight on Glass;* by Thomas Gaffield.

The great attention now given to all the phenomena connected with light and heat may awaken some interest in the experiments in which I have been engaged for the past four years on the subject named at the head of this article. Perhaps I cannot better commence my essay, than by quoting from the "Proceedings of the Natural History Society," (vol. ix, p. 347) an account given before that Society, of my experiments in 1863, and after I had been engaged in them only a few months.

"He believed that his experiments in connection with the subject were original as to their method and their extent, although it had long been observed in Europe that colorless or light-colored plate-glass had turned to a purple hue by exposure to intense sunlight. One case* is cited of a change to a gold color; and one experiment recorded by Dr. Faraday,† some forty years ago, proving that a light purple changed to a darker hue after eight month's exposure.

"Other experiments are on record showing the action of glass of different colors as media in the transmission of light and of heat; but none, with the above exception, showing the effect produced on the glass itself.

"An experience of some twenty years in the window-glass business had only presented a few isolated cases of supposed change of color from this cause, which were attributed to some obvious defect in an article of inferior manufacture; but, within

* Journal of Society of Arts for Feb. 15, 1854.

† Dr. Faraday's Chemical Researches. London, 1859, p. 142.

a short time, he had heard of the change of color in an article of superior manufacture, in a quantity of white plate glass, of which some lights had been broken out of a window in which they had been exposed to the sun.

"This fact coming to his knowledge led him to try an experiment with several specimens of plate, crown, and sheet glass, during the month of July last; which proved that a month's exposure to a hot sun would change the best white French plate and all white sheet glass, such as is used for photographs and engravings, to a color containing more or less of a yellow hue. The dark green and dark blue or bluish green did not experience any change; but any hue which approached a white, whether bluish, greenish, or yellowish white, turned to a yellowish color.

A second series of experiments, commenced in July, and continued three months, on some thirty specimens from France, England, Belgium, Germany, and the United States, only confirmed the results of the first; and a daily examination at first, and afterward from week to week, and month to month, revealed the interesting fact, that, even after a single day's exposure to a July sun, the change of color will, in some instances of the lightest hues, commence.

"So remarkable was the change in a week, affecting nearly all the light-colored glasses, that he commenced a third experiment on the 6th of August which should speak for itself. He then exhibited to the Society ten pieces of French white plate-glass, four by two inches in size (all of which were cut from the same sheet), one of which showed the original colorless glass, and the others exhibiting the change of hue towards yellow, after exposure respectively of one, two, and four days; one, two, and three weeks; one, two, and three months.

"The changes in the first four days were slight; but the last specimens were so yellow as to exhibit a contrast very marked, and excited the interest of all the members present. That the color permeates the body of the glass, and is not confined to the surface, or produced by reflection therefrom, has been conclusively proved by grinding off about one-sixteenth of an inch from both surfaces and the four edges of a duplicate exposed specimen, which, after repolishing, still exhibited the same yellow color.

"The glasses exposed were all what are called colorless window-glasses, although they varied in tinge and hue from the whitest French plate to the darkest green English sheet-glass.

"An experiment for four months, from July to November, on really *colored* glasses, red, green, yellow, blue, and purple, showed no change except in the purple, which became slightly darker.

"The experiments were carried on upon a rough plate-glass roof, nearly horizontal, and which received the rays of the sun

during the greater part of the day. In all cases, strips corresponding to those exposed, and cut off from the same pieces, were placed in the dark, to be compared with the other specimens after exposure.

"It will be noticed that the dark green, blue, and bluish green did not change. The color of the Belgian sheet (called German or French by glass-dealers in America), a yellowish or brownish green, did not change; and these were the only exceptions. All plate-glasses changed, except an inferior blue quality, and a superior crystal plate of a greenish color, made in Germany, and at the only factory which has not given up the use of pot-ash for soda-ash.

"It is possible that a longer exposure of a year, or of years, might change every color in some degree.

"His inquiries, since he instituted these experiments, have brought out some fine specimens of Belgian sheet-glass from a house built three years ago, which had changed in some instances to a golden and in others to the well-known purple hue.

"It is his intention to pursue the experiments farther, with a view to ascertain the effects of sunlight during each month and season of the year; and also whether exposure to heat, air, or moisture alone, out of the direct action of the sun's rays, will produce any corresponding change.

"Mr. Gaffield does not propound any theory to explain these changes of color, which, under our sunny skies, probably take place much more rapidly than in the different and less clear atmosphere of England.

"Some writers point to the presence of oxyd of manganese in the original composition of window-glass, and some to the oxyd of iron, as a chief cause.

"Some writers have peculiar theories about the different classes of the sun's rays. Some may think the change referred to, a molecular or chemical one; and others, wiser than the rest, refrain from any explanation, waiting for a larger multiplication of experiments, and a greater accumulation of facts, before educing any satisfactory law of nature which governs these curious and interesting phenomena.

"Mr. G. makes no pretentions to any discoveries, unless it be to the very rapid change in glass observed in our climate in July, but only gives the result of his experiments, in the hope that the great interest now manifested in the subjects of light and heat may lead others to examine the matter, to repeat the same experiments in other countries, and to give the world the result of their researches, and enable the learned and scientific men of the age to explain this remarkable power and action of the sun's rays.

"It should be remembered that he submitted his specimens to

the most severe tests by placing them where they received reflected as well as transmitted light and heat. The change in glass, when glazed in the windows of our dwellings and stores, is so much more gradual, that it very rarely attracts the attention of observers, except in the marked variation from white to purple."

In accordance with the intention above expressed, I have continued my experiments on this interesting subject, and under different heads will now give some account of their method and results.

My first experiment was with pieces of glass four by six inches, placed in a sash six by sixty inches long, in the grooves of which the specimens were placed, the sash being fastened together by wooden pins, and placed on a nearly horizontal rough plate-glass roof, which received the direct rays of the sun during the greater part of the day. In my next experiment, I placed some of the specimens directly on the rough plate-glass. These were carried on in summer and autumn. It was necessary to make a different arrangement for winter, when the fall of snow and the formation of ice might interfere with the full success of the experiments. I concluded that the best size for specimens was four by two inches, and I made some wooden boxes about $\frac{5}{8}$ inches deep, $4\frac{1}{4}$ inches wide, and of a length to fit the sills of windows facing the south, in the upper story of a Boston house. One of the windows was three-sided, looking east, south, and west. In these boxes, painted white, my specimens were placed in a nearly horizontal position, side by side, and, (after the loss of a few pieces, blown away by hurricanes and squalls), were secured in their positions by cords of twine or slight copper wire fastened at each end. I have arranged boxes on the roof in front of this window also, some being of greater depth in which to place pieces of plate and rough plate about one inch in thickness. All of these boxes are provided with covers, which are placed over the glass, and fastened by buttons, on the occurrence at any time of a snow storm. At all other times, the glass is exposed. Holes in proper places in the boxes allow the rain which falls to pass off easily. Every piece of glass is carefully marked by a diamond in an upper corner with its name, and if necessary, with some abbreviation descriptive of the experiment to which it belongs. This precaution is necessary to prevent mistakes, when a comparison is to be made of several kinds and colors, of exposed and unexposed specimens. In all cases, where an experiment is to be made with any description of glass, the pieces (4×2 inches in size) must all be cut from the same sheet, as there is frequently a slight difference in the shade of sheets from the

same factory, arising from the difficulty of having the materials in their manufacture, and the circumstances attending the melting, blowing or casting precisely the same. Two pieces or more should be laid aside to show the original color, and to compare with the others, and thus to show the changes produced by exposure to sunlight for days, weeks, months or years. At the commencement of an experiment, say for instance, the exposure of white plate-glass for from one to twelve months, a neat paper box is provided, 4¼ inches long, 2⅛ inches deep and wide enough to hold fourteen pieces, (two of the original color, and twelve exposed specimens) and a description of the contents is marked on its cover on an adhesive label. At the end of each month, a piece is withdrawn from exposure, carefully cleaned, and marked either with a diamond or by an adhesive label, and placed in the box. As "order is heaven's first law," it is peculiarly necessary in all observations upon the actions of heaven's brightest luminary. By observing the above directions, much time will be saved, and at the conclusion of an experiment, everything is in shape for exhibition to friends at home, or students at a lecture room.

Of course a *perfect* arrangement could only be made when a perfectly flat roof or platform in an open field could be provided, and the sunlight could act with full force during every hour and minute of the day. But mine was sufficiently near this point to show very interesting results.

In one of my earliest experiments, I kept a record of the changes going on in the various kinds of glass, at first from day to day, and afterwards from week to week, and month to month. The following is a specimen:

Kinds of glass.	Original color before exposure.	Color after one day's exposure.	Here were inserted other columns to show effect of exposure for 2 and 4 days, for 1, 2 and 3 weeks, for 1 and 2 months.	Color at end of exp't. (3 mos.)
French white plate,				
English crown glass.				
French white sheet.				
Belgian sheet.				
American sheet.				

I might give the names of all the different kinds of glass which I have exposed to sunlight, but I refrain because for the reason given previously, I have found different specimens from the same manufactory of plate, of crown, and of sheet-glass, sometimes to differ in shade, sometimes in result of exposure, and sometimes in both.

I will, however, give below, (not naming the particular manufactories), a general description of my experiments in 1863, when an exposure of thirty-three specimens for a few months in summer and autumn showed the following results.

The first table shows that twenty-four kinds were found to be easily affected, and exhibits the time at which the change in color was first observed. The second table shows nine kinds which did not change in color during the same time.

Table of glasses easily changed.

Kinds of Glass.	Original color before exposure.
5 of French white plate.	White, with light bluish green tinge.
2 " German " "	White " " " " "
1 " English white plate.	White " " " " "
5 " " plate.	Yellowish green.
1 " Belgian rough plate.	White, with slight green tinge.
3 " French white sheet.	" with light bluish green tinge.
1 " Belgian " "	" " " yellowish green tinge.
4 " English " "	One light yellowish green and three light bluish green tinge.
2 " American " "	White, with light blue green tinge.
24	

The time at which change of color was first observed.									Color after exposure.
Days.			Weeks.			Months.			
1	2	4	1	2	3	1	2	3	
1		4							Yellow or yellowish green.
1				1					" "
1									" "
	4			1					Deeper yellow tinge.
		1							Yellowish green tinge.
3									" "
1									" "
	1		1	1		1			" "
1		1							" "
8	5	6	1	3		1			

Table of Glasses not changed in three months.

Kinds of glass.	Original color of glass.
1 kind of German crystal plate.	Light green.
1 " " " plate.	Dark blue.
1 " " English rough plate.	Dark green.
1 " " English crown.	Light green.
1 " " American "	Bluish green.
1 " " " sheet.	Dark bluish green.
1 " " English "	Dark green.
1 " " Belgian "	Yellowish or brownish green.
1 " " French "	" " " "
9	

Subsequent experiments with five of these kinds, (all which I could conveniently obtain), showed that an exposure of a year, or even less, would change all but an ordinary kind of American sheet, which was of a dark bluish green color.

The experiments which speak for themselves are the most satisfactory ones, that is to say, where one has not only the

record made at the end of each month, but a piece of glass taken in and laid aside at the same time to show the actual color produced, and the truth of the records. It is very interesting to witness any one of these series of specimens, showing, as in one of white plate, a gradual change, commencing in a day or a few days in summer, from greenish or bluish white to a yellowish white, or light yellow, a deep and deeper yellow, until it becomes a dark yellow or a gold color; and in some Belgian sheet specimens, a gradual change, commencing in a few weeks in summer, from brownish yellow to deeper yellow, yellowish pink, pink, dark pink, purple and deep purple.

There are several kinds of glass in which no perceptible change took place in three months, which were very sensibly affected by an exposure of a year.

Experiments.—I have given a general account of my first experiments in 1863, and a portion of the tables kept in my journal at that time. I might have given names and results in full and shown the actual effects and shades of color produced by exposure for a few months, on some thirty kinds of glass. But in my case, as in many novel and original investigations, the results of first experiments, and the theories based upon them, were modified by subsequent ones. I supposed that many kinds of glass not changed in three months would not change at all: that all which changed would take a yellowish color, unless by exposure of many years: that no color but some shade of yellow or pink would ever be produced in any kind by exposure to sunlight.

The experiments of 1864 and the two following years, proved to me that nearly every kind of window glass I had exposed, could be changed in one year; that a rose or pink color, (or some tint approaching them) could be produced in various kinds in a few months; and that some kinds of greenish white glass would, after exposure, assume a bluish tint or bluish white.

It may seem singular for one who has been a glass dealer and manufacturer like ourselves, thus to advertise what may be called a defect in his own wares. It might seem unkind to other manufacturers to expose the defects of their productions, literally before the light of day. But my scruples have been all removed, when I have noticed in a late communication of Pelouze (see Comptes Rendus, Jan. 14, 1867) the following statement: "I do not believe that there exists in commerce a single species of glass that does not change its shade in the sunlight." As all manufacturers are in the same category, it will do no harm for me to repeat what Pelouze says, as the result of my experiments, and to affirm that a longer or shorter exposure to the direct action of the sun's rays will probably change in some degree the color of all or nearly all kinds of window glass.

I subjoin an account of an experiment carried on for one year with nine different kinds of glasses. These represent plate, crown and cylinder glass, the manufactures of both hemispheres and almost every shade and color of what are called colorless glasses.

I name only the nationalities, and not the particular manufactories of the glasses in any of my tables. I have this information recorded in my journal, and shall be happy to communicate it to any who may desire it.

Memorandum of nine different kinds of glass exposed from Jan. 12, 1866, *to Jan.* 12, 1867.

Kind of glass.	Color before exposure.	Color after exposure.
French white plate.	Bluish white.	Yellowish color.
German crystal plate.	Light green.	Bluish tinge.
English plate.	" "	Yellowish green.
English crown.	" "	Light purplish color.
Belgian sheet.	Brownish yellow.	Deep " "
English sheet.	Dark green.	Brownish green.
American crystal sheet.	Light bluish white.	Purplish white.
" " "	Lighter bluish white.	Light yellowish green.
" ordinary "	Bluish green.	No change.

The colors named above are given from an observation of the glass edgewise, by which one can see a body of color two or four inches in depth, whereas the usual thickness of the glass varies from one-fourteenth to one-quarter of an inch, and shows its color easily only by placing a white curtain or paper behind it.

I have tried several experiments showing the effect of sunlight during each month and each season of the year. At the end of the year, by the comparative depth of yellow or purple color produced in the various specimens, one can see the comparative actinic power of the rays during each month and season. The results proved that the actinic effect increased from January to July, and decreased after that month. The greatest effect during any season was observed in the summer, the least in winter, and that in spring and autumn was about alike, and midway between that of summer and winter.

Crystal or lead glass, and a piece of optical glass having probably very little, if any, manganese, changed not in two years. Perhaps a longer exposure may produce some change.

A rough piece of light colored window glass metal changed to a yellowish color in a year.

Colored glasses after two or three years' exposure showed no perceptible change in any instance except a slight one in a single specimen of purple. Perhaps an exposure of many years may make a change in some other colors.

I have made experiments with artificial heat on glass in various ways, from exposure to the heat of a cooking range oven

to that of a glass stainer's kiln, without any change of color in the common colorless window glasses, while the same or similar specimens exposed to sunlight have been nearly all changed in a few months.

Specimens exposed in hot water for a month, in doors and out of sunlight, experienced no change of color, while similar ones exposed during the same length of time in the bottom of a dish filled with two or three inches of water out of doors, and to the direct rays of the sun, experienced a decided change, though only about half as much as when directly exposed, out of the water.

Being convinced that air, moisture, and artificial heat do not make any change of color, our experiments indicate that the change is effected by the actinic rays of the sun alone.

This actinic effect is cut off in some degree by every medium, by water as stated above, and even by clear glass, as a specimen exposed inside of a window or under another piece of thin colorless glass shows only about one-half as much change, as that exposed outside of the window or with no covering of glass over it. The amount cut off by colorless glass and by colored glass differs greatly with the difference of color.

[To be concluded.]

ART. XXIX.—*Crystallogenic and Crystallographic Contributions;* by JAMES D. DANA.—No. IV. *On a connection between Crystalline form and Chemical constitution, with some inferences therefrom.—Supplement.*

I RETURN to the subject of my article published in the last number of this Journal in order to present a few additional remarks with regard to the bearings of the views on chemical science.

7. *Chemical formulas of the Silicates.*—In the attempts to write the formulas of the Silicates on the new system there has been a difficulty, as the results have shown, in arriving at similar formulas for related species. Part of the diversity in the formulas presented have arisen from the unsettled views among chemists themselves; but another part from the fact that the species vary widely through isomorphous substitutions, and especially through the occurrence, in the basic part, of the elements in different states of oxydation. The method of designating the elements as they exist in these several states by prefixing a Greek letter to the symbol, proposed in my former communication,* affords a convenient means of attaining all the uniformity and simplicity in the formulas that can be desired.

* This volume, page 89.

It will be remembered that the states of R in the oxyds RO, R^2O^3, RO^2, RO^3, RO^5 (which are equivalent to RO, $3(R\frac{2}{3}O)$, $2(R\frac{1}{2}O)$, $3(R\frac{1}{3}O)$, $5(R\frac{1}{5}O)$), or in RS, R^2S^3, RS^2, etc., were made, respectively, the αR, βR, γR, δR, ϵR states, these symbols standing severally for R, $R\frac{2}{3}$, $R\frac{1}{2}$, $R\frac{1}{3}$, $R\frac{1}{5}$ in the above.

The larger part of the silicates are included in two divisions: the *Unisilicate*, and the *Bisilicate*,* as recognized in the edition of my Mineralogy of 1854. The Unisilicates have, on the old system, the general formula $\dot{R}^2\breve{S}i$, when only protoxyds are present, and $(\dot{R}^3, \ddot{R})^2\breve{S}i^3$, when part of the base is sesquioxyd, $\dot{R}^3$ and $\ddot{R}$ being mutually replaceable in different proportions. The Bisilicates have the corresponding formulas $\dot{R}\breve{S}i$ and $(\dot{R}^4, \ddot{R})\breve{S}i^4$. With $\bar{S}i$, the formulas are $\dot{R}^3\bar{S}i$, $(\dot{R}^6, \ddot{R})\bar{S}i$; and $\dot{R}^6\bar{S}i^3$, $(\dot{R}^6, \ddot{R})\bar{S}i^3$.

In writing these formulas on the new system, and adopting the system of symbols for the metal of the corresponding oxyds, αR, βR, etc. (but dropping the α as unnecessary), the formulas above cited become

for the ordinary Unisilicates (1) $\left.\begin{matrix}\mathrm{Si}\\ \mathrm{R_2}\end{matrix}\right\}\mathrm{O_4}$ (2) $\left.\begin{matrix}\mathrm{Si}\\ (\mathrm{R}, \beta\mathrm{R})_2\end{matrix}\right\}\mathrm{O_4}$

for the ordinary Bisilicates (1) $\left.\begin{matrix}\mathrm{SiO}\\ \mathrm{R}\end{matrix}\right\}\mathrm{O_2}$ (2) $\left.\begin{matrix}\mathrm{SiO}\\ (\mathrm{R}, \beta\mathrm{R})\end{matrix}\right\}\mathrm{O_2}$

The silicates of each division, whether containing sesquioxyds, or protoxyds, or both, have on this method essentially the same formulas. Moreover the other states of oxydation may be introduced with the same facility, and thus the remainder of the Unisilicates and Bisilicates be included. We thus bring under two expressions

Unisilicate, $(\mathrm{R_2}, \mathrm{R}, \beta\mathrm{R}, \gamma\mathrm{R}, \delta\mathrm{R})_2\left.\begin{matrix}\mathrm{Si}\end{matrix}\right\}\mathrm{O_4}$, Bisilicate, $(\mathrm{R_2}, \mathrm{R}, \beta\mathrm{R}, \gamma\mathrm{R}, \delta\mathrm{R})\left.\begin{matrix}\mathrm{SiO}\end{matrix}\right\}\mathrm{O_2}$

much the larger part of the silicates, and exhibit to the eye the fact of unity among them, and the truth also that in inorganic nature the types of compounds are few and of the simplest kind. By means of fractional coëfficients the atomic ratios between the R, βR, etc., are easily indicated.

By way of illustration I give below the special formulas of various mineral species under these general formulas, together with those also of the *Subsilicates*. The list is made longer than

* I use these terms in place of *Orthosilicates* and *Metasilicates*, because they express a definite fundamental fact under both the old and new systems of chemistry. In the *Unisilicates*, viewing them with reference to the new system, the two classes of elements combined with the oxygen, that is, the silicon, and R (or the basic metals), have between their *combining powers* the ratio 1 : 1; silicon, a *tetrad*, being associated with *two* basic *dyads*, or their equivalent; while in the *Bisilicates*, this ratio is 2 : 1, silicon being associated with *one* basic dyad or an equivalent. By employing the Latin numerals to express this relation as to combining powers, there is no conflicting with the numerals which are now in use, and which express the ratio between the elements themselves, the latter being all in Greek. Moreover the prefix *meta* in the term *metasilicate* has a diversity of significations in the new chemistry, while etymologically hardly any significancy whatever.

would be necessary for a simple exemplification of the principle, in order to show the efficiency and wide application of the method proposed, and the close parallelisms which it exhibits in the formulas; and also because the subject of the formulas and true relations of the silicates is now attracting much attention.

The formulas beyond are written in a little different manner from what is usual, partly for the sake of compactness on the page, but more because I regard the position of the connecting O *between* the other two members of these ternaries as preferable to that ordinarily given, and better adapted to exhibit on the page the serial analogies and differences of the compounds.

If there are those who would prefer to see the ratios expressed in whole numbers instead of fractions, such can easily gratify themselves in this respect by performing the requisite multiplications. But when this work is done, the result is very far from complete; for in many species, as garnet, epidote, idocrase, pyroxene, hornblende, etc., R corresponds to a number of different elements, as Ca, Mg, Fe, Mn, and sometimes others; and βR to βFe, βAl, βCr, βMn; and several of these different metals may replace one another in the same specimen; and in different proportions in the same mineral from different localities; and the proportions appear to be at times indefinite. To clear away also these fractions arising from isomorphous substitutions would make formulas of great complexity, and in some cases almost as many different ones for a species as there may be localities if not analyses. And besides, the several formulas under a single species thus obtained would differ vastly in the number of atoms which they would indicate to be present in the different representatives of one and the same species, so that nature and chemical art would be put in direct variance.

There is no question that in most cases the formulas beyond should be taken in a multiple form in order to represent the true composition. Moreover, in examples of pleomorphism, such as garnet, allanite and biotite (epidote and idocrase may perhaps be included), the species probably differ by some simple ratio of multiples, as has been already explained. But until the exact multiple in any case has been ascertained, it appears to be best to retain the formula on the unit-scale here adopted. And even when ascertained, it may still be preferable to make the number expressing it a prefix to the whole formula here given, rather than to perform the multiplication with each member of it.

It may be objected to the following formulas that the βFe, βAl, γTi, &c., have only an ideal existence. But if in fact only ideal, they nevertheless belong *fundamentally* to the new system of chemistry. The metal in the sesquioxyds is capable of replacing *three* dyad elements, or *six* monads; and this the symbol recognizes. Moreover Fe^2 in Fe^2O^3 is a mere fiction, except as

regards atomic weight; for Fe^2 is not Fe^2, or *two* of the dyad Fe, as it seems on the face of it to be. The fiction is avoided in the symbol adopted, and without implying any wrong idea with regard to the atomic weights.

Instead of using barred letters for the symbols of the elements whose atomic weights, in the new system, are double those of the old, I have employed small capitals for the remainder of them, that is, those of the perissads. The symbol of a perissad element is also indicated by the index $_2$ annexed to it; 2 of a monad replacing 1 dyad in these oxygen compounds. A list of the perissad elements will be found in the classification of the elements presented on a following page.*

I. Unisilicates.

A. *Anhydrous.*

Forsterite,	$Si\|O_4\|R_2$	$Si\|O_4\|Mg_2$
Fayalite,	"	$Si\|O_4\|Fe_2$
Tephroite,	"	$Si\|O_4\|Mn_2$
Chrysolite,	"	$Si\|O_4\|(Mg, Fe)_2$
Knebelite,	"	$Si\|O_4\|(Fe, Mn)_2$
Willemite,	"	$Si\|O_4\|Zn_2$
Phenacite,	"	$Si\|O_4\|Be_2$
Garnet,	$Si\|O_4\|(R, \beta R)_2$	$Si\|O_4\|(\frac{1}{2}R+\frac{1}{2}\beta R)_2$
Meionite,	"	$Si\|O_4\|(\frac{1}{2}R+\frac{1}{2}\beta R)_2$
Sarcolite,	"	$Si\|O_4\|(\frac{1}{2}R+\frac{1}{2}\beta R)_2$
Allanite,	"	$Si\|O_4\|(\frac{1}{2}R+\frac{1}{2}\beta R)_2$
Epidote,	"	$Si\|O_4\|(\frac{1}{3}R+\frac{2}{3}\beta R)_2$
Zoisite,	"	$Si\|O_4\|(\frac{1}{3}R+\frac{2}{3}\beta R)_2$
Piedmontite,	"	$Si\|O_4\|(\frac{1}{3}R+\frac{2}{3}\beta R)_2$
Mellilite,	"	$Si\|O_4\|(\frac{2}{3}R+\frac{1}{3}\beta R)_2$
Idocrase,	"	$Si\|O_4\|(\frac{3}{5}R+\frac{2}{5}\beta R)_2$
Zircon,	$Si\|O_4\|\gamma R_2$	$Si\|O_4\|\gamma Zr_2$
Biotite,	$Si\|O_4\|(R_2, R, \beta R)_2$	$Si\|O_4\|(\frac{1}{2}(R_2, R)+\frac{1}{2}\beta R)_2$
Phlogopite A,	"	$Si\|O_4\|(\frac{7}{11}(R_2, R)+\frac{4}{11}\beta R)_2$
" B,	"	$Si\|O_4\|(\frac{3}{4}(R_2, R)+\frac{1}{4}\beta R)_2$
Lepidomelane, A,	"	$Si\|O_4\|(\frac{1}{2}(R_2, R)+\frac{1}{2}\beta R)_2$
" B,†	"	$Si\|O_4\|(\frac{1}{3}(R_2, R)+\frac{1}{3}\beta R)_2$
Astrophyllite,‡	$Si\|O_4\|(R_2, R, \beta R, \gamma R)_2$	$Si\|O_4\|(\frac{10}{17}(R_2, R)+\frac{3}{17}\beta R+\frac{4}{17}\gamma(Ti, Zr))_2$
Axinite,	$Si\|O_4\|(R, \beta R, \delta R_2)_2$	$Si\|O_4\|(\frac{2}{7}R+\frac{4}{7}\beta R+\frac{1}{7}\delta B_2)_2$

* The author does not propose to substitute these new formulas for those of the old style in the forthcoming edition of his Mineralogy. They will appear only in tables by the side of the others.

† A is the original Lepidomelane as analyzed by Schlotheim, with which belongs also the Irish analyzed by Haughton. B is that of Rockport, Cape Ann, a brittle ferriferous mica intermediate in ratio between Lepidomelane and the magnesia mica, Biotite.

‡ From Pisani's analysis, C. R., lvi, 846.

B. *Hydrous.*

Calamine,	$Si\|O_4\|R_2+naq$	$Si\|O_4\|Zn_2+\frac{3}{2}aq$
Cerite,	"	$Si\|O_4\|(Ce, La, Di)_2+aq$
Thorite,	"	$Si\|O_4\|Th_2+2aq$
Serpentine,*	$Si\|O_4\|(H_2, R)_2+naq$	$Si\|O_4\|(\frac{1}{4}H_2+\frac{3}{4}Mg)_2+aq$
Deweylite,	"	$Si\|O_4\|(\frac{1}{5}H_2+\frac{4}{5}Mg)_2+\frac{3}{5}aq$
Hydrophite,	"	$Si\|O_4\|(\frac{1}{3}H_2+\frac{2}{3}(Mg, Fe))_2+\frac{4}{3}aq$
Genthite,	"	$Si\|O_4\|(\frac{1}{3}H_2+\frac{2}{3}(Mg, Ni))_2+\frac{4}{3}aq$
Ekmannite,†	"	$Si\|O_4\|(\frac{1}{3}H_2+\frac{2}{3}(Fe, Mn))_2+\frac{1}{3}aq$
Kaolinite,*	$Si\|O_4\|(H_2, \beta R)_2+naq$	$Si\|O_4\|(\frac{1}{2}H_2+\frac{1}{2}\beta Al)_2+aq$
Gillingite,	$Si\|O_4\|(R, \beta R)_2+naq$	$Si\|O_4\|(\frac{1}{2}R+\frac{1}{2}\beta Fe)_2+2aq$
Hisingerite,	$Si\|O_4\|(H_2, R, \beta R)_2+naq$	$Si\|O_4\|(\frac{1}{3}H_2+\frac{2}{3}(R, \beta Fe))_2+\frac{4}{3}aq$
Neotocite,	"	$Si\|O_4\|(\frac{1}{3}H_2+\frac{2}{3}(R, \beta Mn))_2+\frac{4}{3}aq$
Triclasite (Fahlunite),	"	$Si\|O_4\|(\frac{1}{3}H_2+\frac{1}{3}R+\frac{1}{3}\beta Al)_2$
Killinite,	"	$Si\|O_4\|(\frac{1}{3}H_2+\frac{2}{3}(R, \beta Al))_2$
Prehnite,	"	$Si\|O_4\|(\frac{1}{6}H_2+\frac{2}{6}Ca+\frac{3}{6}\beta Al)_2$
Pinite,*	$Si\|O_4\|(H_2, R_2, R, \beta R)$	$Si\|O_4\|(\frac{1}{2}H_2+\frac{1}{4}(K_2, R, \beta Al))_2$
Margarodite,	"	$Si\|O_4\|(\frac{2}{6}H_2+\frac{1}{6}(K_2, R)+\frac{6}{6}\beta Al)_2$
Œllacherite,‡	"	$Si\|O_4\|(\frac{1}{6}H_2+\frac{1}{6}(K_2, R)+\frac{4}{6}\beta Al)_2$
Paragonite,	$Si\|O_4\|(H_2, R_2, \beta R)$	$Si\|O_4\|(\frac{2}{12}H_2+\frac{1}{12}Na_2+\frac{9}{12}\beta Al)_2$
Damourite,	"	$Si\|O_4\|(\frac{2}{12}H_2+\frac{1}{12}K_2+\frac{9}{12}\beta Al)_2$
Euphyllite,	$Si\|O_4\|(R_2, \beta R)+naq$	$Si\|O_4\|(\frac{1}{6}(K, Na)_2+\frac{3}{6}\beta Al)_2+\frac{1}{2}aq$

In several of the above species the water is all basic; in the others partly or wholly an accessory ingredient.

C. *With other accessory ingredients instead of water.*

Helvite,	$Si\|O_4\|R_2+$	$Si\|O_4\|(\frac{1}{2}(Mn, Fe)+\frac{1}{2}Be)_2+\frac{1}{6}MnS$
Danalite,	"	$Si\|O_4\|(\frac{1}{2}Mn, Fe, Zn)+\frac{1}{2}Be)_2+\frac{1}{6}ZnS$
Sodalite,	$Si\|O_4\|(R_2, \beta R)_2+$	$Si\|O_4\|(\frac{1}{4}Na_2+\frac{1}{4}\beta Al)_2+\frac{1}{3}Nacl$
Hauynite,	"	$Si\|O_4\|(\frac{1}{4}(R_2, R)+\frac{2}{4}\beta Al)_2+\frac{1}{3}S^a$
Nosite,	"	$Si\|O_4\|(\frac{1}{4}Na_2+\frac{2}{4}\beta Al)_2+\frac{1}{6}T^b$

[a] S=anhydrous sulphate of calcium. [b] T=anhydrous sulphate of sodium.

* Serpentine, Kaolinite and Pinite are closely related in formula. The oxygen ratio for the bases, silica and water, in the first two is 3 : 4 : 2, in the last, 3 : 4 : 1. Pinite is an alumina-alkali serpentine, and Kaolinite (Pholerite, in part) an alumina serpentine, as pyrophyllite is an alumina talc.

Pinite includes many pseudomorphous potash silicates; as Liebnerite, Gieseckite, Dysyntribite, Pinitoid, Wilsonite, Lythrodes, Fellenberg's green mineral resembling compact green talc from the moraine of the Grindelwald glacier; and Gigantolite, Iberite, Polyargite, Rosellan appear to be impure conditions of the species.

† B. H. Ztg., xxvi, 21, 1867.

‡ Œllacher's margarite from Pfitschthal, Kenngott's Uebers., 1860, 49. The author has learned from Dr. Krantz that the margarite analyzed by Prof. G. J. Brush, to whom he furnished the specimen, is the original margarite, and that therefore Œllacher's is not so. Dr. Krantz in a note dated Bonn, March 17, 1867, says: "The specimen of margarite Prof. Brush obtained from me came from the Greiner mount in Tyrol. It occurs there in irregular masses in the mica slate in several varieties, passing from a pearl-white color into green and gray; it was formerly a very common mineral, but has of late become scarce. This was the only known locality in Tyrol, till Œllacher analyzed a mica of similar appearance, occurring with Rhætizite very near Kemmat in the Pfitsch valley in Tyrol, containing barytes, to which also he gave the name margarite. The two localities are about two and a half German or twelve English miles in a direct line from one another."

The species here included are all of the isometric system, the system which is peculiarly defiant of change from isomorphous substitutions; and they are alike of the *garnet* group.

II. Bisilicates.

A. *Anhydrous.*

Wollastonite,	$SiO\|O_2\|R$	$SiO\|O_2\|Ca$
Enstatite,	"	$SiO\|O_2\|Mg$
Kupfferite,	"	$SiO\|O_2\|Mg$
Grünerite,	"	$SiO\|O_2\|Fe$
Rhodonite,	"	$SiO\|O_2\|Mn$
Pyroxene,	"	$SiO\|O_2\|(Ca, Mg, Fe, Mn)$
Hypersthene,	"	$SiO\|O_2\|(Mg, Fe)$
Anthophyllite,	"	$SiO\|O_2\|(\frac{3}{4}Mg+\frac{1}{4}Fe)$
Amphibole, A,	"	$SiO\|O_2\|(Mg, Ca, Fe, Mn)$
" B,	"	$SiO\|O_2\|(H_2, Mg, Ca, Fe, Mn)$*
Babingtonite,	$SiO\|O_2\|(R, \beta R)$	$SiO\|O_2\|(\frac{2}{3}(Fe, Mn)+\frac{1}{3}\beta Fe)$
Beryl,	"	$SiO\|O_2\|(\frac{1}{2}Be+\frac{1}{2}\beta Al)$
Ægirine,	$SiO\|O_2\|(R_2, R, \beta R)$	$SiO\|O_2\|(\frac{1}{2}(Na_2, R)+\frac{1}{2}\beta Fe)$
Wichtisite,	"	$SiO\|O_2\|(\frac{1}{2}(Na_2, R)+\frac{1}{2}\beta Al)$
Acmite,	"	$SiO\|O_2\|(\frac{1}{3}(Na_2, R)+\frac{2}{3}\beta Fe)$
Arfvedsonite,	"	$SiO\|O_2\|(\frac{2}{3}(Na_2, R)+\frac{2}{3}\beta Fe)$
Spodumene,	$SiO\|O_2\|(R_2, \beta R)$	$SiO\|O_2\|(\ (Li_2, Na_2)+\frac{4}{3}\beta Al)$
Cryophyllite,	"	$SiO\|O_2\|(\frac{3}{7}(K_2, Li_2, R)+\frac{4}{7}\beta Al)$
Eudialyte,	$SiO\|O_2\|(R_2, R, \gamma R)$	$SiO\|O_2\|(\frac{1}{3}(Na_2, R)+\frac{1}{3}\gamma Zr)$†

B. *Hydrous.*

Talc, A,	$SiO\|O_2\|(H_2, R)$	$SiO\|O_2\|(\frac{1}{3}H_2+\frac{2}{3}Mg)$
" B,	$SiO\|O_2\|(H_2, R)+naq$	$SiO\|O_2\|(\frac{1}{3}H_2+\frac{2}{3}Mg)+\frac{1}{15}aq$
Sepiolite (Meerschaum),	"	$SiO\|O_2\|(\frac{1}{4}H_2+\frac{3}{4}Mg)+\frac{1}{4}aq$
Pyrophyllite,	$SiO\|O_2\|(H_2, \beta R)+naq$	$SiO\|O_2\|(\frac{1}{3}H_2+\frac{2}{3}\beta Al)+\frac{1}{12}aq$
Cimolite,	"	$SiO\|O_2\|(\frac{1}{4}H_2+\frac{3}{4}\beta Al)+\frac{1}{4}aq$
Okenite,	$SiO\|O_2\|(H_2, R)+naq$	$SiO\|O_2\|(\frac{1}{3}H_2+\frac{1}{3}Ca)+\frac{1}{3}aq$
Laumontite,	$SiO\|O_2\|(R, \beta R)+naq$	$SiO\|O_2\|(\frac{1}{2}Ca+\frac{1}{2}\beta Al)+aq$
Pectolite,	$SiO\|O_2\|(H_2, R_2, R)$	$SiO\|O_2\|(\frac{1}{6}H_2+\frac{5}{6}(Na_2, Ca))$
Dioptase,	$SiO\|O_2\|R+naq$	$SiO\|O_2\|Cu+aq$

III. Subsilicates.

In the Subsilicates, the combining power of the silicon is less than that of the basic metal, the oxygen ratios for the bases and silicon being 3 : 2, 2 : 1, and 4 : 3, of which 3 : 2 is the most common. The only silicates of aluminum (or of an element in the beta state) known among minerals are Subsilicates; all the Uni-

* Much amphibole contains some water; and according to Lechartier 1 to 1·5 p. c. exist in ordinary tremolite and other varieties, and this water requires a red heat to expel it. Making the water basic the ratio becomes 2 : 1 when not so without.

† Rammelsberg's analysis makes the oxygen ratio for $\dot{R}$, $\ddot{R}$, $\dot{S}i$=8·93 : 4·44 : 26·62 =2 : 1 : 6.

silicates and Bisilicates containing aluminum contain also one or more basic metals in the *protoxyd* state.

The formulas of the mineral species here included are as follows, if the oxygen be not divided—the only method according to which they have been written in recent works on chemistry.*

A. *Anhydrous.*

	Ratio.		
Chondrodite,	4 : 3	$R_3\|(O, F)_{14}\|Si_2$	$Mg_3\|(O, F)_{14}\|Si_2$
Tourmaline,	4 : 3	$(\dot{H}_2, R, \beta R, \delta R_2)_3\|(O, F)_{14}\|Si_2$	$(\dot{H}_2, R, \beta Al\ \delta B_2)_3\|(O, F)_{14}\|Si_2$
Andalusite,	3 : 2	$\beta R_3\|O_5\|Si$	$\beta Al_3\|O_5\|Si$
Sillimanite,	3 : 2	"	$\beta Al_3\|O_5\|Si$
Kyanite,	3 : 2	"	$\beta Al_3\|O_5\|Si$
Gehlenite,	3 : 2	$(R, \beta R)_3\|O_5\|Si$	$(\frac{1}{2}R+\frac{1}{2}\beta R)_3\|O_5\|Si$
Sphene,	3 : 2	$(R, \gamma R)_3\|O_5\|Si$	$(\frac{1}{2}Ca+\frac{1}{2}\gamma Ti)_3\|O_5\|Si$
Tscheffkinite,	3 : 2	"	$(\frac{2}{3}R+\frac{2}{3}\gamma Ti)_3\|O_5\|Si$
Grothite,†	3 : 2	$(R, \beta R, \gamma R)_3\|O_5\|Si$	$(\frac{2}{3}Ca+\frac{1}{3}\beta Fe+\frac{2}{3}\gamma Ti)_3\|O_5\|Si$
Keilhauite,	3 : 2	"	$(\frac{5}{13}R+\frac{3}{13}\beta R+\frac{7}{13}\gamma Ti)_3\|O_5\|Si$
Topaz,	3 : 2	$\beta R_3\|(O, F)_5\|Si$	$\beta Al_3\|(\frac{1}{4}O+\frac{1}{4}F)_5\|Si$
Staurolite,‡	2 : 1	$(\dot{H}_2, R, \beta R)_4\|O_6\|Si$	$(\frac{1}{3}(\dot{H}_2, R)+\frac{1}{3}\beta R)_4\|O_6\|Si$
Schorlomite,	2 : 1	$(R, \beta R, \gamma R)_4\|O_6\|Si$	$(\frac{4}{11}R+\frac{3}{11}\beta R+\frac{4}{11}\gamma R)_4\|O_6\|Si$

B. *Hydrous.*

	Ratio.		
Pyrosclerite,	4 : 3	$(\dot{H}_2, R, \beta R)_8\|O_{14}\|Si_3+naq$	$(\frac{1}{2}\dot{H}_2+\frac{2}{3}R+\frac{1}{3}\beta R)_8\|O_{14}\|Si_3+2aq$§
Pennine,	"	$(R, \beta R)_8\|O_{14}\|Si_3+naq$	$(\frac{2}{3}R+\frac{1}{3}\beta R)_8\|O_{14}\|Si_3+4aq$‖
Ripidolite,	"	"	$(\frac{2}{3}R+\frac{2}{3}\beta R)_8\|O_{14}\|Si_3+4aq$‖
Cookeite,	"	$(\dot{H}_2, R_2, \beta R)_8\|O_{14}\|Si_3+naq$	$(\frac{1}{12}\dot{H}_2+\frac{1}{12}(Li, K)_2+\frac{10}{12}\beta Al)_8\|O_{14}\|Si_3+3aq$

* The principles of the new system seem to suggest for the rational formula one of the two following methods; which of the two, I leave for others to decide.

	Ratio 3 : 2.	Ratio 2 : 1.	Ratio 4 : 3.
I.	$(R, \beta R)O\|O_4\|Si$	$(R, \beta R)O_2\|O_4\|Si$	$(R, \beta R)O_2\|O_{12}\|Si_3$
II.	$(R, \beta R)O_2\|O_2\|SiO$	$(R, \beta R)O_2\|O_2\|SiO$	$(R, \beta R)O_2\|O_2\|Si_2O_3$

† Described as a variety of Titanite by Groth in the Jahrb. Min., 1866, p. 44.

‡ Lechartier has found (Bull. Soc. Ch., II, iii, 378, 1865) that the variations in the silica, etc., observed in staurolite by Rammelsberg are due to impurities, and that after separating the impurities, the amount of silica is uniformly 28·1 to 29·2 p. c.; and further, that 1·3 to 1·5 p. c. of water were present in the pure staurolite, which required near red heat to expel it.

§ From von Kobell's analysis. The ratio is 1 : 1 if the water be excluded; but 4 : 3 as in Pennine, if half the water be made basic. As in the case of the silicate group generally, and many other hydrous silicates, the true constitution must remain in doubt until the state of the water has been definitively determined.

‖ Pennine affords in part the ratio 5 : 4, but 4 : 3 is probably the true ratio. Optically Pennine is hexagonal, and *Ripidolite* (Clinochlore) monoclinic. Von Kobell's name, Ripidolite, has priority; and, moreover, a second kind of Clinochlore or monoclinic Chlorite exists; the *Corundophilite* of Chester, Mass., having been found to have the optical bisectrix oblique to the plane of cleavage by Descloizeaux, and later by Prof. J. P. Cooke (this vol., p. 206). There are hence *two hexagonal* and *two monoclinic* chlorites. The Corundophilite approaches more nearly the hexagonal chlorite in composition than Ripidolite (Clinochlore); the formula for it is from Pisani's analysis, whose specimens were optically examined by Descloizeaux.

Since *Chlorite* has become the name of a group of species, the hexagonal chlorite requires another name; and it is accordingly designated above *Prochlorite*, it being the *first* crystallized chlorite recognized by Werner.

Euclase,	3 : 2	$(H_2, R, \beta R)_3 \vert O_5 \vert Si$	$(\frac{1}{6}H_2+\frac{2}{6}Be+\frac{3}{6}\beta Al)_3 \vert O_5 \vert Si$
Datolite,	"	$(H_2, R, \delta_R)_3 \vert O_5 \vert Si$	$(\frac{1}{6}H_2+\frac{2}{6}Ca+\frac{3}{6}B_2)_3 \vert O_5 \vert Si$
Prochlorite,	"	$(R, \beta R)_2 \vert O_5 \vert Si+naq$	$(\frac{4}{5}R+\frac{1}{5}\beta Al)_3 \vert O_5 \vert Si+1\frac{1}{2}aq$*
Cronstedtite,	"	"	$(\frac{1}{2}R+\frac{1}{2}\beta Fe)_3 \vert O_5 \vert Si+1\frac{1}{2}aq$
Corundophilite,	2 : 1	$(R, \beta R)_4 \vert O_6 \vert Si+naq$	$(\frac{1}{4}R+\frac{1}{4}\beta R)_4 \vert O_6 \vert Si+1\frac{3}{8}aq$*
Chloritoid,	"	"	$(\frac{1}{2}R+\frac{1}{2}\beta R)_4 \vert O_6 \vert Si+aq$
Margarite,	"	$(H_2, R, \beta R)_4 \vert O_6 \vert Si$	$(\frac{1}{5}H_2+\frac{1}{5}R+\frac{3}{5}\beta R)_4 \vert O_6 \vert Si$
Thuringite,	"	"	$(\frac{1}{6}H_2+\frac{2}{6}R+\frac{3}{6}\beta R)_4 \vert O_6 \vert Si$
Seybertite,	3 : 1	$(R, \beta R)_6 \vert O_8 \vert Si+naq$	$(\frac{2}{3}R+\frac{1}{3}\beta R)_6 \vert O_8 \vert Si+\frac{1}{2}aq$†
Xanthophyllite,	4 : 1	$(R, \beta R)_8 \vert O_{10} \vert Si+naq$	$(\frac{3}{5}R\overline{+}\frac{1}{5}\beta R)_8 \vert O_{10} \vert Si+aq$‡

The species Ilvaite, from Elba, appears from the analyses to fall among Subsilicates. But the oxygen ratio between the basic metals and the silicon varies in the analyses from 5 : 4 to 9 : 8; and in the mineral from Nassau, regarded as the same species (Tobler, Journ. Ch. Pharm., xcix, 122), the ratio is 1 : 1. Städeler states that 1 to 2 p. c. of water is always present which is expelled only by the heat of ignition; and making the water basic, arrives at the ratio 5 : 4 for the species. Another view, perhaps quite as probable, considering the opacity of the species and Lechartier's results with staurotide, is that the mineral of Elba contains some $\dot{F}e\dot{H}$ (Göthite) as impurity; and that this causes the divergence from the ratio 1 : 1.

IV. Intermediate Silicates.

The silicates in which the oxygen ratio for the basic metals and silicon is between 1 : 1 and 1 : 2 have been called *Parasilicates* by Odling, being regarded as combinations of a Unisilicate and Bisilicate. The ratio

1 : $1\frac{1}{2}$,	occurs in	Leucophane and Lepidolite,	and would correspond to	1U + 2B
1 : $1\frac{1}{3}$	"	Muscovite and Iolite,	"	"	$1\frac{1}{2}$U + 1B
1 : $1\frac{1}{5}$	"	Nepheline,	"	"	$3\frac{1}{2}$U + 1B

The discovery by Prof. J. P. Cooke of a bisilicate mica, cryophyllite, has led this chemist to sustain the view that the micas are isomorphous combinations of the above kind, the group now including three or more Unisilicates, one Bisilicate, and the two intermediate species, lepidolite and muscovite.

Besides the above species of intermediate silicates there are the various compounds grouped under the species Wernerite (Scapolite) together with the related Meionite and Mizzonite. The minerals here alluded to have the same crystallization and belong to one group, and, according to Rose, and others to one species, Meionite. The divergence from the unisilicate ratio has

* See note (‖) on preceding page.

† From the analyses by Brush, who obtained but 1·50 p. c. of water, more than half less than other analysts had found.

‡ From Meitzendorf's analyses.

been attributed to alteration, and to impurities; and also by others to a variation in chemical ratio analogous to that among the feldspars. I pass the subject without discussion.

The species of Silicates which remain are the Feldspars and the Zeolites. The Feldspars may be regarded as *unisilicate* in anorthite; *bisilicate* in andesine and leucite; *tersilicate* in albite and orthoclase; $1\frac{1}{2}$-*silicate* in labradorite; $2\frac{1}{2}$-*silicate* in oligoclase. But this view would disband one of the most natural groups of silicates, and introduce the only example of a *tersilicate* among anhydrous silicates. I have seen no satisfactory explanation of the unity of the group, and am not prepared to offer one. The theory of the Zeolites seems to be one with that of the Feldspars.*

* Tschermak has proposed a method of deducing a common formula for the Feldspars which has had some favor, and may have here a passing remark. At the extremes in the series of feldspars are *Anorthite* and *Albite*, the former containing calcium, aluminum and silicon, with the oxygen ratio 1 : 3 : 4; and the latter sodium, aluminum and silicon, with the ratio 1 : 3 : 12. Tschermak brings these extremes under one formula as follows. By making the number of atoms of oxygen in the two the same (which is done by doubling the Anorthite), the sum of the number of equivalents of aluminum and silicon (taking silica as SiO^2) in the two is the same; and also, if we write Na_2 for Na, in accordance with the new chemistry, the number of atoms of protoxyds is the same. Then, assuming that the Al and Si are replaceable 1 for 1, and K, Ca, 1 for 1, the formulas become, for

Albite, $Na^2\ Al^2\ Si^3\ Si^4\ O^{16}$

Anorthite, $Ca^2\ Al^2\ Al^2\ Si^4\ O^{16}$

and are parallel throughout. The result *looks* well. But this substitution, atom for atom, of a tetrad (Si) and a pseudotriad (Al), and also of a monad (Na) and a dyad (Ca), is an impossibility. It takes two of a monad to replace a dyad.

If silicon may be basic and replace aluminum it is a much simpler method of arriving at like formulas for the species (and one correct in the ratio in which Si and Al may replace one another) to make a direct transfer as follows: The first column contains the oxygen ratios, as ordinarily given; the second, the same with part of the silica transferred to the bases and added to the alumina; the third, the resulting general ratio for the bases and silica.

	Oxygen ratio. R : R : Si	Oxygen ratio. R : Al+Si : Si	Oxygen ratio. Bases : Silica.
Anorthite,	1 : 3 : 4	1 : 3 + 0 : 4	1 : 1
Labradorite,	1 : 3 : 6	1 : 3 + 1 : 5	1 : 1
Andesite,	1 : 3 : 8	1 : 3 + 2 : 6	1 : 1
Oligoclase,	1 : 3 : 9	1 : 3 + $2\frac{1}{2}$: $6\frac{1}{2}$	1 : 1
Albite, Orthoclase,	1 : 3 : 12	1 : 3 + 4 : 8	1 : 1

The species are thus all reduced to *Unisilicates*, of the Anorthite and Garnet type, with the general formula

$$Si|O_4|(R_2, R, \beta Al, \gamma Si)_2;$$

and, accordingly, the following would be the special formulas of Anorthite, Labradorite and Albite:

Anorthite, $Si|O_4|(\frac{1}{2}R+\frac{1}{2}\beta Al)_2$

Labradorite, $Si|O_4|(\frac{1}{5}(Na_2, Ca)+\frac{2}{5}\beta Al+\frac{1}{5}\gamma Si)_2$

Albite, $Si|O_4|(\frac{1}{8}Na_2+\frac{1}{8}\beta Al+\frac{1}{8}\gamma Si)_2$

Formulas for the others may be written in the same manner.

8. *Classification of the Elements.*—On page 94 of my former paper, it was stated, among the inferences from the principles discussed, that the metals in their different states, as indicated by their different grades of combinations, that is, αR, βR, γR, δR, εR, should be arranged in different groups in a classification of the elements. This principle has been, in part, for some time admitted. The following scheme of classification, thus made out, in brief, is here introduced as a supplement to the preceding tables of formulas, to make more manifest the general relations of the elements in their different states, and to present to view the author's reasons for regarding zirconium in zircon, eudialyte, astrophyllite, etc.; titanium in sphene, keilhauite, astrophyllite, etc.; boron in axinite, datolite, tourmaline, *basic* metals, and the compounds with silicon silicates, while at the same time the near relation between these metals and silicon is fully admitted.

Classification of the Elements.

Series I.	**Series II.**	**Series III.**
A. *Perissads* (Monads).	A. *Perissads.*	A. *Perissads* (Monads).
Potassium, Sodium, Cæsium, Rubidium, Lithium, Thallium, Hydrogen, Silver, Gold.	Nitrogen, Phosphorus, Arsenic, Antimony, Bismuth, Columbium, Tantalum. Boron.	Chlorine, Bromine, Iodine.
B. *Artiads.*	B. *Artiads.*	B. *Artiads.*
1. Iron-Aluminum Group.	1. Sulphur Group.	
a. Iron Sub-group. — Platinum, etc., Copper, Lead, etc., Iron, Cobalt, Zinc, Cadmium, Nickel, Manganese, Chromium, Tungsten, etc., Cerium, Yttrium, etc., Magnesium, Calcium, Strontium, Barium; also H_2, K_2, Na_2, etc.		*a.* Fluorine.
b. Aluminum Sub-group.— Aluminum (βAl); also βFe, βMn, βCr, etc.	Sulphur (δS), Selenium, Tellurium, Molybdenum; also δFe, δCr, δMn, δV, δW, δAS_2, δB_2.	*b.* Oxygen.
2. Tin Group.	2. Carbon-Silicon Group.	
Tin, Titanium, Zirconium, Thorium; also γH, γFe, γMn, γCo, γPb, γCu, etc.	Carbon, Silicon; also γS, γSe, γTe, etc.	

It is observed that in this classification *three* series of elements are recognized, which are designated by numbers, Series I, II, III. They might be called the *basic, medial,* and *acidic* series; or the *basic, subacidic,* and *peracidic.* But it seems as well to call them simply by their numbers, since, owing to the diversities

among the species of each series, the above descriptive names are only in a general way, and not specifically, applicable.

The classification is, in our view, a natural one, whether read vertically or transversely.

Looking at it vertically, the three series correspond severally with the three grades of elements in the oxygen ternary compounds or salts, the acidic element being of Series III; the second element in order, silicon, of Series II; and the basic metals of Series I. The elements of Series I are eminently the basic elements. Among those of Series II arsenic and others of the first group often replace isomorphically sulphur of the second group; and RO^2 of the sulphur group makes salts that are isomorphous with those of CO^2. The near relations of the species of Series III have always been recognized.

Viewing the arrangement horizontally, the three Divisions A, at the top of the series, include the Perissads, or those elements the ratios of whose combinations are by *odd* numbers, as 1 : 1, 1 : 3, 2 : 3, etc.; while the three Divisions B, across, include the Artiads, or those whose combinations are by *even* numbers, as 2 : 2 (in the Iron Sub-group), 4 : 6 (in the Aluminum Sub-group), 2 : 4 (in the Tin Group and Carbon-Silicon Group), 2 : 6 (in the Sulphur Group). The recognition of this distinction of odd and even is universally regarded as one of the most important deductions of modern chemical science.

Again, opposite the Iron-Aluminum Group in Series I, stands the Sulphur group in Series II; and many metals which are represented in the Iron-Aluminum Group are also represented in the Sulphur Group. Again, Oxygen, of Series III, stands opposite Sulphur of Series II, whose relations to oxygen are fundamental.

Again, the Tin Group in Series I is in the same horizontal division with the Carbon-Silicon Group in Series II. The mutual relations of the two are thus recognized; and, also, by the arrangement in distinct series, the actual diversity as to their grade in ternaries. For silicon stands on a virtually higher level than tin and titanium, and throws the latter into the inferior basic relation whenever they occur together. As Ti joins with Fe to form with oxygen a sesquioxyd, closely isomorphous with hematite (Fe^2O^3) and also physically like it, so Ti may join with Ca (as in Perofskite) or with any other metal of that sub-group, in a sesquioxyd; and so also it may be basic in any combination with silica, as in sphene, etc., page 258. Accordingly, also, SiO^2 and ZrO^2 make together, not a mere combination of two coördinate isomorphs, but a true Unisilicate, as recognized in the formula on page 255. The formulas of the silicates which have been given and the classification we regard as mutually illustrating and sustaining one another.

Fluorine is placed among the Artiads, because of its frequent replacement of oxygen, the analogies of its ternaries with those of oxygen, and the nature of some other of its compounds, although it acts in many cases as a Perissad. But with regard to it no special relation in a horizontal view of the classification is intended to be indicated.*

ART. XXX.—*Formic versus Carbonous acid;* by GEORGE F. BARKER.

IN studying the primary oxyds of the negative simple radicals, (the acids) for the purpose of classification, it is evident that the equivalence of the radical varies in each of the acids which it forms. In sulphuric acid, sulphur is a hexad, while in sulphurous acid it is a tetrad and in hyposulphurous acid a dyad. Conversely we may expect to find as many acids as the radical by such changes in its equivalence, can produce. Phosphoric acid contains phosphorus as a pentad; but since this radical may act as a triad, phosphorous acid is thus predicted. In the case of the tetrad carbon we have carbonic acid; but since carbon may act as a dyad, carbonous acid is also possible. I propose to give here some of the arguments which may be adduced to show that formic acid is the acid in question.

1. The formula of formic acid, usually written $\left.\begin{matrix}(\text{C}\text{H}\Theta)\\ \text{H}\end{matrix}\right\}\Theta$, may equally well be written $\left.\begin{matrix}\text{C}''\\ \text{H}_2\end{matrix}\right\}\Theta_2$, both being equal to $\text{H}_2\text{C}\Theta_2$, corresponding to carbonic acid $\text{H}_2\text{C}\Theta_3$. Potassic formate $\left.\begin{matrix}(\text{C}\text{H}\Theta)\\ \text{K}\end{matrix}\right\}\Theta$ equals $\left.\begin{matrix}\text{C}\\ \text{HK}\end{matrix}\right\}\Theta_2$, and the ethers $\left.\begin{matrix}(\text{C}\text{H}\Theta)\\ (\text{C}_n\text{H}_{2n+1})\end{matrix}\right\}\Theta$ may be $\left.\begin{matrix}\text{C}\\ \text{H}(\text{C}_n\text{H}_{2n+1})\end{matrix}\right\}\Theta_2$.

2. Hofmann's formamid $\left.\begin{matrix}(\text{C}\text{H}\Theta)\\ \text{H}\\ \text{H}\end{matrix}\right\}\text{N}$ may be viewed as $\left.\begin{matrix}(\text{C}'')\text{H}_2\text{N}\\ \text{H}\end{matrix}\right\}\Theta$ carbimic acid, corresponding to carbamic acid $\left.\begin{matrix}(\text{C}\Theta)\text{H}_2\text{N}\\ \text{H}\end{matrix}\right\}\Theta$. Especially since ethyl-formamid $\left.\begin{matrix}(\text{C}\text{H}\Theta)\\ \text{C}_2\text{H}_5\\ \text{H}\end{matrix}\right\}\text{N}$ may be ethylic carbimate $\left.\begin{matrix}(\text{C}'')\text{H}_2\text{N}\\ \text{C}_2\text{H}_5\end{matrix}\right\}\Theta$.

* Near the last of June, Prof. G. Hinrichs, of Iowa University, published in German a memoir on *Atom Mechanics*, which, while the views are widely different, has some points of agreement with my paper in the July number of this Journal. A copy of the memoir reached this place July 2d, after my paper was printed, but nearly three weeks before the July number was issued. I had intended to have an abstract of it in this number, but am unable to accomplish it, and therefore defer it to our next.

3. The radical formyl ($\mathrm{CH\Theta}$), unlike acetyl ($\mathrm{C_2H_3\Theta}$), is not required to formulate the derivatives of the acid. Moreover, no chlorid or hydrid of this radical exists. The anhydrous acid (formylic oxyd), too, $\left.\begin{matrix}(\mathrm{CH\Theta})\\(\mathrm{CH\Theta})\end{matrix}\right\}\Theta$ is unknown. If, however, the acid be $\left.\begin{matrix}\mathrm{C}\\\mathrm{H_2}\end{matrix}\right\}\Theta_2$, then its secondary oxyd would be $\mathrm{C''}\}\Theta$, carbonic oxyd.

4. Its synthesis. We have—*a*, Berthelot's method,
$\mathrm{HK\Theta+C\Theta=HKC\Theta_2}$; just as $\mathrm{HK\Theta+S\Theta_2=HKS\Theta_3}$.

b, Kolbe's method by deoxydizing $\mathrm{H_2C\Theta_3}$,
$\mathrm{(H_2C\Theta_3)_2+Na_2=HNaC\Theta_2+HNaC\Theta_3+H_2\Theta}$.

c, Dupré's method, $\mathrm{H_2C\Theta_2+C+H_2\Theta=(H_2C\Theta_2)_2}$; similar to $\mathrm{H_2S\Theta_3+S+H_2\Theta=(H_2S\Theta_2)_2}$.

d, Chapman's method, partial oxydation of carbon,
$\mathrm{C+\Theta+H_2\Theta=H_2C\Theta_2}$.

5. Its preparation. *a*, from oxalic acid $\mathrm{H_2C_2\Theta_4=H_2C\Theta_2+C\Theta_2}$, as well as the reverse action; *b*, from cyanhydric acid
$$\left.\begin{matrix}\mathrm{C''}\\\mathrm{H}\end{matrix}\right\}\mathrm{N}+\left.\begin{matrix}\mathrm{H_2}\\\mathrm{HK}\end{matrix}\right\}\Theta_2=\left.\begin{matrix}\mathrm{C''}\\\mathrm{HK}\end{matrix}\right\}\Theta_2+\left.\begin{matrix}\mathrm{H_2}\\\mathrm{H}\end{matrix}\right\}\mathrm{N}.$$
And in general its production from the oxydation of carbonaceous materials. In no case is the intermediate body formic aldehyd, obtained; this anomalous result is accounted for if the acid be $\left.\begin{matrix}\mathrm{C''}\\\mathrm{H_2}\end{matrix}\right\}\Theta_2$.

6. Its decompositions. Like sulphurous and similar acids, it readily reduces metallic salts; it is oxydized readily by platinum black; by action of $\mathrm{H_2S\Theta_4}$, $\mathrm{H_2C\Theta_2}$ gives $\mathrm{H_2\Theta}$ and $\mathrm{C\Theta}$, the anhydrid; the action of $\mathrm{PCl_5}$ produces no formylic chlorid, $\mathrm{H_2C\Theta_2+PCl_5=PCl_3\Theta+C\Theta+(HCl)_2}$; chlorine gives $\mathrm{H_2C\Theta_2+Cl_2=C\Theta_2+(HCl)_2}$.

7. Its acknowledged divergence from the acetic or fatty acid series, in which it is usually classed. These acids resist the oxydizing action of dilute chromic acid, while formic acid on the other hand is a powerful reducing agent.

From the above statements, it is clear that this question turns on the fact whether this acid is mono or dibasic. Just now, the former has the preference. True we may view the formates as acid carbonites, but the anomaly of an acid, all of whose salts are acid salts, remains. A basic plumbic formate $\left.\begin{matrix}\mathrm{Pb''}\\\mathrm{H(CH\Theta)}\end{matrix}\right\}\Theta$, corresponding to the acetate $\left.\begin{matrix}\mathrm{Pb''}\\\mathrm{H(C_2H_3\Theta)}\end{matrix}\right\}\Theta$, if known, might have the formula $\mathrm{Pb''C\Theta_2+H_2\Theta}$, plumbic carbonite.

The fact of its formation by the partial oxydation of carbon, and also, by the deoxydation of carbonic acid, are however, most cogent arguments in favor of the acid of bivalent carbon.

New Haven, Sept. 1st, 1867.

ART. XXXI.—*Observations on Skylight Polarization in Nebraska during the month of July*, 1867; by EDWARD O. CHASE.

THE following observations were made at various stations of the U. S. Geological Survey, with an excellent Savart polariscope, of remarkable clearness. I mark the neutral points as follows: Ar., Arago's; Ba., Babinet's; Br., Brewster's.

July 1.—Cloudy.

2.—$6^h\ 30^m$ P.M., Ar., Ba., both faint. Clouds below the sun.

3, 4.—Cloudy.

5.—12 M., Br., distinct. $6^h\ 30^m$ P.M., Ba., faint.

6.—Heavy rain in A.M. $6^h\ 30^m$ P.M., Ba., faint.

7.—$7^h\ 15^m$ A.M. and $5^h\ 45^m$ P.M., Ba., faint.

8.—$6^h\ 10^m$ A.M., Ar., distinct, Ba., faint. $6^h\ 30^m$ P.M., Ar., Ba., equally distinct.

9.—Cloudy in A.M. 7^h P.M., Ar., faint; Ba., distinct.

10.—Ba., distinct; Br., faint. Stormy in P.M.

11.—Cloudy and stormy.

12.—$8^h\ 30^m$ A.M., Ba., Br., both faint. 7^h P.M., Ar., Ba., equally distinct.

13.—7^h A.M., Ar., distinct; Ba., faint. $7^h\ 15^m$ P.M., Ar., very distinct; Ba., distinct.

14.—Cloudy and rainy.

15.—$6^h\ 30^m$ A.M., Ar., very distinct; Ba., faint; Br., distinct. This was the only instance in which the three points were observed simultaneously.* $7^h\ 25^m$ P.M., Ar., very distinct; Ba., faint.

16.—8^h A.M., Ba., very distinct; Br., faint. 7^h P.M., Ar., very distinct; Ba., faint.

17, 18.—Cloudy.

19.—$6^h\ 30^m$ P.M., Ar., very distinct; Ba., distinct.

20.—6^h P.M., Ar., very distinct.

21.—6^h A.M., Ar., very distinct; Ba., distinct.

22.—6^h P.M., Ar., Br., equally distinct. $7^h\ 15^m$ P.M., Ar., very distinct; Ba., distinct.

23.—$7^h\ 30^m$ P.M., Ar., very distinct; Ba., distinct.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the synthesis of organic acids.*—CARIUS has made the very interesting and important discovery that chlorous acid like hypochlorous acid unites directly with hydrocarbons to form chlorinated organic acids. In his first memoir the author describes the product of the action of chlorous acid upon benzol under the name of trichlorphenomalic acid, the reaction by which the new acid is formed being represented by the equation $\mathrm{C_6H_6 + (ClHO_2)_3 = C_6H_7Cl_3O_5 + OH_2}$.

* For analogous observations see this Journal, II, xlii, 112, 113.

Trichlorphenomalic acid may be regarded as a chlorinated derivative of an acid homologous with malic acid, $\Theta_3\left\{\begin{matrix}\text{C}_6\text{H}_7\Theta_2\\ \text{H}_3\end{matrix}\right.$; the acid is colorless, crystalline and soluble in water, alcohol, benzol and ether. Its density when fused and solidified is 1·5, at 131°–132° C. it fuses, and at a few degrees higher gives off vapors of water and a new acid. Reducing agents convert the acid apparently into another acid having the formula $\text{C}_6\text{H}_{10}\Theta_5$, but with a larger excess of tin, and strong chlorhydric acid succinic acid is formed, with small quantities of another acid not yet studied. With an excess of solution of baryta trichlorphenomalic acid yields a new acid, the reaction being

$$\text{C}_6\text{H}_7\text{Cl}_3\Theta_5+(\text{BaH}\Theta)_6=3\text{BaCl}+\text{C}_6\text{H}_3\text{Ba}_3\Theta_6+5(\Theta\text{H}_2).$$

The author terms this acid phenaconic acid, and describes a number of its salts. In addition to the crystallized trichlorphenomalic acid, an amorphous acid having the same constitution is found among the products of the action of chlorous acid upon benzol. This acid yields with reducing agents new acids free from chlorine which with their salts are also amorphous. Chemists will await with much interest the results of the researches of Carius upon the action of chlorous acid upon naphtalin which promise to connect this body with the aromatic and through this with the fatty series.—*Ann. der Chemie und Pharm.*, cxlii, 129. W. G.

2. *On the action of heat upon benzol and analogous hydrocarbons.*—Berthelot has studied the action of heat upon various hydrocarbons and has arrived at many interesting and valuable results. When benzol is passed through a porcelain tube heated to bright redness, it is partially decomposed with formation of several definite hydrocarbons which stand in very simple relations to benzol itself. The chief product is phenyl, a beautiful crystalline substance which has the formula

$$(\text{C}_{12}\text{H}_5)_2=\text{C}_{24}\text{H}_{10}\,(2\text{C}_{12}\text{H}_6=\text{C}_{24}\text{H}_{10}+2\text{H}).$$

The author considers it as formed from benzol by the replacement of two atoms of hydrogen by an equal volume of benzol so that C_{12}H_4 (C_{12}H_6) results. The phenyl obtained in this way is identical with that Fittig obtained by the action of sodium upon brominated benzol, but the method of preparation is more advantageous than that of Fittig. Above 360° C., a waxlike yellowish substance very slightly soluble in alcohol passes over, which is identical with chrysen. Berthelot gives this body the formula $\text{C}_{36}\text{H}_{12}$, ($3\text{C}_{12}\text{H}_6=\text{C}_{36}\text{H}_{12}+6\text{H}$) and considers it a polymer of the unknown hydrocarbon C_{12}H_4. After chrysen an orange colored resinous solid body passes over which is almost insoluble in alcohol which it however causes to fluoresce and which gives with picric acid a slightly soluble peculiar compound. In the retort there remains a fluid hydrocarbon which does not volatilize at a red heat and which on cooling gives a black and brittle bitumen. All these hydrocarbons result from the condensation of a variable number of molecules of benzol with evolution of hydrogen. Naphtalin and anthracen are not present even in small quantities. Toluol like benzol is partially decomposed by passing through a red hot tube. The products of the action by careful rectification were found to be benzol in large quantity, unaltered toluol in still larger quantity, naphtalin, a small quantity of a crystallized hy-

drocarbon boiling at about 270° C., and a larger quantity of a fluid hydrocarbon which is perhaps benzyl $(C_1H_7)_2$ or an isomer. The boiling point then rises above 360° C., when a large quantity of an indistinctly crystallized hydrocarbon passes over mixed with a liquid. The first is anthracen $(C_{14}H_5)_2$; the others are analogues of chrysen and the last derivatives of benzol. Benzyl is derived from toluol in the same manner a sphenyl from benzol; $2C_{14}H_8=C_{28}H_{14}+H_2$. Anthracen is derived from toluol by a similar condensation and subtraction of hydrogen $2C_{14}H_8=C_{28}H_{10}+3H_2$. As, according to Berthelot's view, toluol may be derived from benzol by the substitution of marsh-gas for hydrogen, benzol $=C_{12}H_4(H_2)$, toluol $=C_{12}H_4(C_2H_2)$. Anthracen may be considered as formed by the union of the benzol residue $C_{12}H_4$ with the marsh-gas residue C_2H and has therefore the rational formula $[C_{12}H_4(C_2H)]_2$, that is, $C_{12}H_4[C_{12}H_4(C_4H_2)]$. This explains why a marsh-gas residue is necessary for the formation of anthracen and why this hydrocarbon is not formed in the decomposition of pure benzol. The formation of benzol from toluol is according to all analogy, being merely the derivation of a lower from a higher homologue. The marsh-gas residue serves to form naphtalin according to the equation

$$4C_{14}H_8=3C_{12}H_6+C_{20}H_8+3H_2.$$

When a mixture of benzol and ethylen, C_4H_4, is passed through a red hot tube the following products are obtained. (1) Styrolen $C_{16}H_8$ in large quantity well defined and without any more volatile product, except benzol; (2) naphtalin, $C_{20}H_8$; (3) another crystallizable hydrocarbon resembling phenyl and boiling at about 260° C., but forming a characteristic compound with picric acid which phenyl does not do; (4) anthracen in considerable quantity mixed with a fluid hydrocarbon, etc. The formation of styrolene may be represented by the equation

$$C_{12}H_6+C_4H_4=C_{16}H_8+H_2.$$

Naphtalin is formed by the reaction $C_{12}H_6+2C_4H_4=C_{20}H_8+3H_2$, which, according to Berthelot, leads to the rational formula, $C_{12}H_4[C_4H_2(C_4H_2)]$, so that naphtalin is formed from benzol by two successive substitutions, one of H_2 by C_4H_4 forming styrolene, $C_{12}H_4(C_4H_4)$, the second of H_2 in C_4H_4 by C_4H_2. Anthracen is formed according to the reaction $2C_{12}H_6+C_4H_4=C_{28}H_{10}+3H_2$.

which leads to the rational formula $C_{12}H_4[C_{12}H_4(C_4H_2)]$.

Pure styrolene is partially decomposed at a red heat with formation of benzol and acetylene $C_{16}H_8=C_{12}H_6+C_4H_2$.

Again benzol and acetylene heated together produce a certain quantity of styrolene, though this hydrocarbon is not the chief product. When styrolene and hydrogen, $C_{16}H_8+H_2$, are heated together in a closed tube, benzol and ethylene are formed. In this case, however, the greater part of the styrolene is directly converted into benzol according to the equation $3C_{16}H_8=4C_{12}H_6$.

Styrolene and ethylene heated together, $C_{16}H_8+C_4H_4$, yield benzol and naphtalene both in considerable quantity. The benzol results from the decomposition of the styrolene itself but the naphtalin is formed by the direct action of ethylene upon styrolene:

$$C_{12}H_4[C_4H_2(H_2)]+C_4H_2(H_2)=C_{12}H_4[C_4H_2(C_4H_2)]+2H_2.$$

Benzol and styrolene passed together through a red hot tube gave anthracene in large quantity, together with naphtalin and a hydrocarbon resembling phenyl. The anthracene results from the direct action of the styrolene upon benzol according to the equation

$$C_{12}H_4[C_4H_2(H_2)]+C_{12}H_4(H_2)=C_{12}H_4[C_{12}H_4(C_2H_2)]+2H_2.$$

Berthelot thinks that in this case the naphtalin results from the action of the free hydrogen upon the styrolene forming ethylene and benzol, while the ethylene reacts upon another portion of styrolene to join naphtalin. Benzol and naphtalin exert no action upon each other at a red heat, but the benzol is alone decomposed. At a bright red heat anthracene is found in large quantity.

$$C_{12}H_4[C_4H_2(C_4H_2)]+3C_{12}H_4(H_2)=2C_{12}H_4[C_{12}H_4(C_4H_2)]+3H_2.$$

Phenyl heated to redness with hydrogen in a closed glass tube is partially decomposed with formation of benzol and chrysen:

$$3C_{24}H_{10}=3C_{12}H_6+C_{36}H_{12}.$$

In this case phenyl, $C_{12}H_4(C_{12}H_6)$, separates into benzol and phenylene, which last is then converted into its polymer chrysen, $C_{36}H_{12}=(C_{12}H_4)_3$. —*Comptes Rendus*, lxiii, 788, 834. W. G.

3. *On the acids of the lactic series.*—By the action of metallic zinc upon a mixture of iodid of amyl and oxalate of ethyl, FRANKLAND and DUPPA have obtained the ethers of several new acids belonging to the lactic series. The ether with the lowest boiling point, 203° C., has the formula $\mathfrak{C}_9H_{18}\Theta_3$. The authors assign to it the rational formula

$$^{*}\left\{\begin{matrix}\mathfrak{C}\text{AmHHo}\\ \mathfrak{C}\Theta\text{Eto}\end{matrix}\right.$$

calling it amyl-hydroxalate of ethyl and regarding it as oxalate of ethyl in which one atom of oxygen is replaced by one of amyl and one of hydrogen. This body may be compared with lactate of ethyl from which it may be theoretically derived by replacing an atom of methyl by an atom of amyl.

$$\left\{\begin{matrix}\mathfrak{C}\text{MeHHo}\\ \mathfrak{C}\Theta\text{Eto}\end{matrix}\right. \qquad \left\{\begin{matrix}\mathfrak{C}\text{AmH, Ho}\\ \mathfrak{C}\Theta\text{Eto}\end{matrix}\right.$$

Lactate of ethyl. Amyl hydrate of ethyl.

The new ether is a rather oily, transparent, faintly straw-yellow liquid of density 0·9449 at 13° C., with an agreeable odor and burning taste.

A second ether formed at the same time has the formula $\left\{\begin{matrix}\mathfrak{C}\text{AmHEto}\\ \mathfrak{C}\Theta\text{Eto}\end{matrix}\right.$ The authors term it ethylated amyl-hydroxalate of ethyl. Its density is 0·9399 at 13° C.; it boils at 224°–225°, is faint yellow, and oily with an aromatic somewhat amylic odor and burning taste.

A third ether has the formula

$$\left\{\begin{matrix}\mathfrak{C}\text{Am}_2\text{Ho}\\ \mathfrak{C}\Theta\text{Eto}\end{matrix}\right.$$

The authors term this liquid diamyloxalate of ethyl; it closely resembles these last mentioned in appearance and properties. From the ethers the authors have also prepared the corresponding acids, for the description of which, however, we must refer to the original paper.

* Am=$\mathfrak{C}_5H_{11}$, Et=$\mathfrak{C}_2H_5$, Ho=(HΘ), Eto=$C_2H_5\Theta$), &c.

The action of zinc upon a mixture of iodid of ethyl and oxalate of amyl gives rise to a new ether which the authors term diethoxalate of amyl and which has the formula $\begin{cases} \text{C}_2\text{Et}_2\text{Ho} \\ \text{CO}_2\text{Amo} \end{cases}$. It is colorless and oily with an agreeable somewhat amylic odor and boils at 225° C. It will be readily seen that this ether is isomeric with ethylated amyl-hydroxalates of ethyl. By the action of zinc upon a mixture of iodid of amyl and oxalate of amyl the authors obtained two ethers, the first of which has the formula $\begin{cases} \text{C}_2\text{Am}_2\text{Ho} \\ \text{CO}_2\text{Amo} \end{cases}$ and may be termed diamyloxalate of amyl, while the second had the formula and properties of capronic ether $\begin{cases} \text{CBuH}_2 \\ \text{CO}_2\text{Ago} \end{cases}$. In conclusion the authors give an elaborate and extremely interesting discussion of the classification and theory of the acids of the lactic series, for which however we must refer to the original. The following summary of their results is in their own language.

(1.) All the acids of the lactic series are essentially monobasic.

(2.) These acids are of four kinds, namely, normal, secondary, normal olefine acids and secondary olefine acids; and each of these has its own series of etheric acids in which the hydrogen of the hydroxyl contained in the positive or basylous constituent of the acid is replaced by a positive or negative compound radical.

(3.) The normal acids are derived from oxalic acid by the replacement of one atom of oxygen either by two atoms of hydrogen, or by one atom of hydrogen and one atom of an alcohol radical.

(4.) The secondary acids are derived from oxalic acid by the replacement of one atom of oxygen by two atoms of monovalent alcoholic radicals.

(5.) The olefine acids are derived from oxalic acid by a similar substitution of two positive monovalent radicals in place of one atom of oxygen with the simultaneous insertion of an olefine hydrocarbon or divalent radical C_nH_{2n} between the two atoms of oxatyl.

(6.) The acids of the lactic series stand to the acids of the acetic series in the very simple relation just pointed out by Kolbe; namely, that if in any acid of the lactic series, the hydroxyl, ethoxyl, etc., in the positive radical is replaced by hydrogen this acid is converted into a member of the acetic series.

(7.) The acids of the lactic series stand in an almost equally simple relation to the acids of the acrylic series as appears from a comparison of the following formulas: $\begin{cases} \text{C}(\text{CH}_3)\text{HHo} \\ \text{CO}_2\text{Ho} \end{cases}$ $\begin{cases} \text{C}(\text{CH}_2)''\text{H} \\ \text{CO}_2\text{Ho} \end{cases}$.

Lactic acid.

—*Ann. der Chemie und Pharmacie*, cxlii, 1. W. G.

4. *Thallic acid.*—E. Carstanjen states that when thallic oxyd, precipitated from the chlorid of ammonia, is suspended in a strong solution of potash, gently heated, and a quick current of chlorine gas passed through the liquid, it becomes of an intense violet red color, and contains potassic thallate. It may be evaporated, and even filtered through paper, but is decomposed by acids, evolving oxygen. The author is still at work upon this interesting compound.—*J. pr. Ch.*, ci, 55, June, 1867.

. 5. *The new Chemical Calculus.*—On the 3d of May, 1866, Sir BENJAMIN BRODIE, Professor of Chemistry in the University of Oxford, read a paper before the Royal Society, entitled "The Calculus of Chemical operations; being a method for the investigation by means of symbols, of the laws of the distribution of weight in chemical change; Part I. On the construction of Chemical Symbols." This paper was published in the Philosophical Transactions for 1866, part II, 856, and, in abstract, in the Philosophical Magazine, IV, xxxii, 227. On the 6th of June, 1867, Prof. Brodie delivered a lecture before the Chemical Society, "On the mode of representation afforded by the chemical calculus, as contrasted with the atomic theory," which was quite fully reported in the "Chemical News" of June 14, and the "Laboratory" of the 15th, together with the subsequent discussions by Professors Frankland, Williamson, Odling, Foster, Wanklyn, Maxwell, etc. Of the critical articles called forth by Sir Benjamin Brodie's communications, those of Williamson, Chem. News, xvi, 3, July 5; of Wanklyn and Davey, Phil. Mag., IV, xxxiv, 26, July, 1867; of Kekulé, The Laboratory, i, 303, July 27; and of A. Crum Brown, Phil. Mag., IV, xxxiv, 129, August, may be mentioned. The views of Prof. Kekulé, contained in the first of a series of papers on Theoretical Chemistry, contributed to that valuable little journal, are stated so clearly, and at the same time are so just, that we reproduce the article entire. It should be remarked, however, that Professor Brodie's "Ideal Chemistry" is to be comprised in three papers, the 1st being on "The construction of chemical symbols;" the 2nd on "The theory of chemical equations;" and the 3d on "The principles of symbolic classification." Only the first of these has yet appeared. G. F. B.

On the existence of Chemical atoms; by AUG. KEKULÉ.

The question whether atoms exist or not has but little significance in a chemical point of view; its discussion belongs rather to metaphysics. In chemistry we have only to decide whether the assumption of atoms is an hypothesis adapted to the explanation of chemical phenomena. More especially have we to consider the question, whether a further development of the atomic hypothesis promises to advance our knowledge of the mechanism of chemical phenomena.

I have no hesitation in saying that, from a philosophical point of view, I do not believe in the actual existence of atoms, taking the word in its literal signification of indivisible particles of matter. I rather expect that we shall some day find, for what we now call atoms, a mathematico-mechanical explanation, which will render an account of atomic weight, of atomicity, and of numerous other properties of the so-called atoms. As a chemist, however, I regard the assumption of atoms, not only as advisable, but as absolutely necessary in chemistry. I will even go further, and declare my belief that *chemical atoms exist*, provided the term be understood to denote those particles of matter which undergo no further division in chemical metamorphoses. Should the progress of science lead to a theory of the constitution of chemical atoms—important as such a knowledge might be for the general philosophy of matter—it would make but little alteration in chemistry itself. The chemical atom will always remain the chemical unit; and for specially chemical con-

siderations we may always start from the constitution of atoms, and avail ourselves of the simplified expression thus obtained, that is to say, of the atomic hypothesis. We may, in fact, adopt the view of Dumas and of Faraday, "that whether matter be atomic or not, thus much is certain, that granting it to be atomic, it would appear as it now does."

After these remarks, it is scarcely necessary to say that I set but small value on most of the attacks recently made against the atomic hypothesis. In many of them I see merely words and phrases, not ideas. It is, however, quite otherwise with the endeavors of those who seek to discover chemical laws independently of the atomic hypothesis. All endeavors of this kind possess great merit; and if they lead to actual results, the laws thus discovered independently of the atomic hypothesis, will be reducible to that hypothesis, and will follow as consequences from it, always supposing that the atomic hypothesis itself is true.

Brodie's 'Calculus of Chemical Operations' is an attempt of this kind. But the talented author of these speculations evidently goes too far, when he declares "that Dalton's theory is inadequate for present purposes, and that it could no longer be advantageously used to elucidate the work carried on by chemists;" and when he adds "that chemistry had got on the wrong track—off the rails, in fact."

A final verdict on these speculations cannot at present be pronounced, seeing that we have before us merely the method of drawing conclusions, and the application of this method to the construction of formulæ for the elements and for particular compounds. The author promises, indeed, that his method will present numerous and important advantages, and he hopes, further, "to be able to express, by formulæ, dynamical facts;" but all these points are reserved for future communications. We may, however, even now assert that the published results, and especially the formulæ given for the elements and compounds, possess no advantage whatever over the views now universally received. They contain, like those hitherto in use, only statics, and no dynamics, and although we are assured "that they express by symbols, the exact facts of chemistry," it is impossible not to perceive that these symbols involve an almost unlimited number of hypotheses for which there is no proof whatever.

For the elements, Brodie, as is well known, comes to the conclusion that there exist three groups, expressible by the symbols—

$$x \qquad y^2 \qquad x+y^2.$$

All elements belonging to the third group (chlorine, bromine, iodine, nitrogen, etc.) are regarded as compounds. They are not, indeed, supposed to contain two kinds of matter at present unknown in the separate state; but the much less admissible hypothesis is made that they consist of a constituent hitherto unknown in the isolated state, combined with *hydrogen*.

Such an assumption is so directly at variance, not only with all views hitherto received, but with the entire range of known facts, that it requires to be tested with all possible circumspection.

Even admitting at the outset that Brodie's speculation is founded "on a very fair amount of hypothesis," we cannot avoid seeing at the first glance that it leads to hypotheses of most astounding character, and on closer examination we are inevitably led to the conclusion that the entire

speculation is based on pure caprice. Its foundation involves especially the three following hypotheses:

(1) Hydrogen must be assumed as the starting point.

(2) Hydrogen is an element.

(3) Hydrogen is the result of a single operation, therefore $= \alpha$.

With regard to the first, it must, at all events, be admitted that, instead of hydrogen, any other element ought to be admissible as the starting-point of the system. But if chlorine ($= \chi$) or nitrogen ($= \nu$) had been selected for this purpose, no calculation could have led to the conclusion that these bodies contain hydrogen. Now, it is clear that a system of symbols cannot be admitted as a true representation of actual facts, unless its results are independent of the particular member of the system which has been taken as a starting-point for the construction of the whole.

The second hypothesis, that hydrogen is an element, might have been admitted without remark by every chemist who regards as elements all bodies not hitherto decomposed; but the author of the speculations now under consideration is under an obligation to show grounds for such an assumption, inasmuch as he comes to the conclusion that others of the so-called elements are compounds.

The third point, and perhaps the most important in connection with results, is no less hypothetical. Why is hydrogen regarded as the result of a single operation, and not as the result of two, seeing that oxygen, sulphur, etc., are supposed to result from two operations? We are assured, "There were strong reasons for preferring the use of the system in which α was employed to present the standard amount of matter;" but these reasons are not yet made known, and therefore their value cannot be appreciated. So much, however, is certain, that, if instead of α, the expression α^2 had been chosen for the purpose just mentioned, Brodie's own form of reasoning would have led to formulæ identical in every particular with those now in use. All bodies which we now regard as elements would, or, at least, might have been found to be such; and for all compounds, the system in question would have led to the very formulæ which have long been used by the adherents of the atomic molecular theory.

The hypothesis, hydrogen $= \alpha$, is said to be the simplest that could be adopted; but it may be laid down as a general rule that, in selecting from a number of different hypotheses the one which is most probable on the ground of simplicity, it is necessary to look, not only to the relative simplicity of the hypothesis itself, but to the more or less simple character of the consequences which follow from it.

Had the author of the "Calculus of Chemical Operations" merely expressed an opinion that the formulæ which he has constructed for elements and compounds are "one of the different expressions" which, according to the principle of prime factors, are deducible from the known facts connected with relations of volume, everybody would have agreed with him. We should have perceived (though, perhaps, with some surprise) that our existing hypotheses are not the only ones capable of accounting for these relations of volume; and we should have been strengthened in the conviction that the correctness of our present theories and formulæ does not depend for its proof on volume-relations alone. But the author of this new mode of representation goes further. Among

other things he plainly puts forward the view that many of the substances now regarded as elements contain hydrogen; and suggests that, even if the elements which are combined with hydrogen in these compounds do not exist in the free state on our earth, they may possibly exist in that state in other parts of the universe.

No one will maintain that the bodies which we now call elements are necessarily and absolutely undecomposable. But if, on the other hand, it be asserted that our existing elements are actually of compound nature, the establishment of such a proposition will certainly require more than the simple observation, that a result of the kind may possibly be deduced from a kind of reasoning founded upon hypothesis. We shall, at least, require proof that such an assumption is calculated to lead to useful results, and that it presents decided advantages over our present views. If it be maintained that many of the substances now regarded as elementary contain a substance at present unknown in the free state, combined with another body—hydrogen, for example—which we do not know in that state, we may, certainly, require the assertion to be proved by the actual separation of hydrogen from these substances. In default, however, of further knowledge, we may hold fast by the principle announced by Dalton, "that a substance, till it is decomposed, must be regarded, according to the just logic of chemistry, as an elementary substance."

II. MINERALOGY AND GEOLOGY.

1. *Notice of volume IV of the Paleontology of New York, by the Author.* 24 pp., 8vo. Albany, March, 1867.—Owing to the length of time required to complete the numerous plates of the fourth volume of his great work on the Paleontology of New York, Professor Hall has here given in advance a brief statement of the contents of this volume sometime since printed. The third volume, the text of which appeared in 1861, comprises the fossils of the Lower Helderberg and the Oriskany sandstone; and it is an exceedingly rich volume in its contents, its plates numbering nearly 140, and including a great variety of species among Crinoids, Brachiopods, Acephals, Gasteropods, Orthocerata, Trilobites and Eurypterids, all evincing a vast amount of careful research. The *fourth* volume, as the "Notice" states, takes up the following formations of the Devonian, the Upper Helderberg, Hamilton, Portage and Chemung, and as the number of species in these rocks is very great, Professor Hall confines himself here to the *Brachiopods*, deferring to a future volume the remainder of the species. We take the following facts from this Notice.

The order adopted, and the list of genera under which the species are described or discussed, are as follows:—Lingula, Discina, Crania, Pholidops (=Pseudocrania), Orthis, Streptorhynchus, Strophomena, Strophodonta, Chonetes, Productus, Strophalosia and Productella, Spirifera, Cyrtina and Cyrtia, Trematospira, Rhynchospira, Nucleospira, Retzia, Athyris, Meristella and Meristina, Pentagonia, Atrypa, Cœlospira, Rhynchonella =Stenocisma, Leiorhynchus, Leptocœlia, Camarophoria, Pentamerus, Stricklandinia, Pentamerella, Gypidula, Amphigenia and Rensselæria, Terebratula, Cryptonella, Centronella, Tropidoleptus, Vitulina.

The Lingulæ of the Upper Helderberg are *L. ceryx, desiderata, Manni;* of the Hamilton group, *L. exilis, ligea,* var., *palæformis, leana* (n. s.), *maida* (n. s.), *punctata* (n. s.), *nuda* (n. s.), *densa* (n. s.), *delia* (n. s.), *alveata* (n. s.), *spatulata;* of the Chemung group, *L. melia* (n.s.), *Cuyahoga* (n.s.).

The Discinæ of the Hamilton group are, *Discina minuta, humilis* (n. s.), *grandis, Randalli* (n. s.), *Doria* (n. s.), *seneca* (n. s.), *media* (n. s.), *Tullia* (n. s.), *Lodensis, truncata;* of the Chemung group, *Discina neglecta* (n. s.), *D. Elmira* (n. s.), *Alleghania, Newberryi* (n. s.).

Of the genus Crania, the *C. Aurora* (n. s.), occurs in the Schoharie grit; in the Hamilton, are *C. Hamiltonæ, crenistriata,* and *gregaria,* or the young of *C. Hamiltonæ;* in the Chemung, *C. Leoni.*

Of the genus Pholidops, two species, *P. areolata* (n. s.), and *P. Hamiltonæ,* occur in the Hamilton group.

The species of Orthis, of the Upper Helderberg are, *O. peloris* (n. s), *lenticularis, alsus* (n. s.), *mitis* (n. s.), *livia, similis* (n. s.), *cleobis* (n. s.), *idas* (n. s.), *propinqua;* of the Hamilton, *Orthis solitaria, lepida, Vanuxemi, leucosia, Penelope, cyclas, idoneus* (n. s.), *Tulliensis;* of the Portage and Chemung groups, *O. carinata, Tioya* (n. s.), *impressa, Leonensis* (n. s.), *Thiemei,* and *leucosia?*

Under the genus Streptorhynchus, several species heretofore described are referred to *Strophomena* (*Streptorhynchus*) *Chemungensis* Conrad, under which, as varieties, are arranged *Strophomena bifurcata, S. arctostriata, S. pectinacea,* and *Orthis perversa* (Hall); *Streptorhynchus pandora* (Billings); *Orthisina arctostriata* and *O. alternata* (Hall); *Orthis inequalis* and *O. pravus* (Hall, Iowa Report). The species is extremely variable, having a great vertical and horizontal distribution, and appears under many phases.

The *Strophomena rhomboidalis* (Wahlenberg)=*S. rugosa* (Rafinesque) occurs in the Schoharie grit, and is abundant in the Corniferous limestone, but is unknown in the Hamilton and Chemung groups.

The genus Stropodonta extends throughout the series; and two species, the *S. demissa* and *S. perplana,* are found from the Schoharie grit to the Chemung group inclusive. The species recognized in the Upper Helderberg group are, *S. demissa, perplana, alveata, callosa, parva, crebristriata, inequiradiata, Patersoni, hemispherica, inequistriata, ampla;* in the Hamilton group, *S. concava, perplana* Conrad (which has been described under the names *Strophomena perplana, S. pluristriata* and *S. delthyris* Conrad; and as *S. nerovsa, S. crenistriata* and *S. fragilis* Hall); *demissa, nacrea, inequistriata, jumia;* in the Chemung, *S. Cayuta* (n. s.), *mucronata, cælata* (n. s.), *perplana* var. *nervosa, demissa.*

In the genus Chonetes, we find verified in a very satisfactory manner the observations made by Count von Keyserling, in regard to the direction of the tubes or spine-bases in the area of the ventral valve. These tubes are directed from the hinge-line toward the apex of the valve, and parallel to the sides of the triangular fissure. They appear on the crest of the area as little pustules or elongated tubular spines, which may be either vertical to the hinge-line or directed outward. The species of the Upper Helderberg and Hamilton groups are, *C. hemispherica, arcuata, acutiradiata, lineata, Yandellana, mucronata, deflecta, pusilla, setigera, scitula, lepida, coronata, Logani.*

The occurrence of the *C. Logani* in the Tully limestone carries back the appearance of this species to a much earlier epoch than had heretofore been known. The species is not known in the Chemung group within the State; though found in the sandstones of the same age in Ohio, and in the beds at the base of the Burlington limestone in Iowa and Illinois.

In the Chemung group we have the recurrence of *Chonetes scitula*, *C. lepida* and *C. setigera;* with a new and remarkable species, the *C. muricata*, which has the apex truncated and the surface of the ventral valve ornamented with spines, but having the vascular markings peculiar to the genus.

Under the head of Productus and Strophalosia, the relations of these genera and of the genus Aulosteges are discussed. The Devonian species, sometimes referred to Strophalosia, are shown to have a narrow area, but with internal vascular impressions like Productus. The absence of an area in the genus Productus is not uniform, as is shown in *P. costatus* of the Carboniferous system in America; and the same has been shown by Mr. Davidson to be true of *P. sinuatus* and *P. semireticulatus* of Europe.

In comparing the American Devonian forms of Productidæ with the Strophalosia of the Permian system, the former have a greater width on the hinge-line, and in this respect more resemble typical Productus; while the narrow cardinal area and hinge-teeth assimilate them with Strophalosia. Notwithstanding this feature, the vascular markings are like Productus. At this epoch we have the earliest known appearance of these forms, the type of which becomes extravagantly developed in the Carboniferous period, and, waning during the Permian epoch, is presented for the most part in degenerate modifications of the typical forms. Although we cannot shut our eyes to this fact of development to what may be termed the perfection of the type, and its more abrupt decline, we are either compelled to extend the characters of Productus so as to cover the two forms or modifications indicated, or else to propose a distinct designation. The latter course has been adopted, and the name Productella is proposed for the strophaloid Productids of the Devonian period.

The subgenus Productella is compared as follows, in Pal. N. Y., vol. IV, page 153: "These shells differ from Strophalosia in the extremely narrow linear cardinal area, greater extension of the hinge-line, more extreme arcuation or ventricosity of the ventral valve in many or most of the species, and especially in the direction and termination of the reniform vascular impressions, which resemble those of Aulosteges and of some species of Productus. It differs from Productus in the constant presence of an area, hinge-teeth and sockets."

The Productellæ of the Upper Helderberg and Hamilton groups mentioned are, *P. subaculeata*, *navicella*, *Shumardiana*, *spinulicosta*, *truncata*, *dumosa*, *exanthemata*, *Tullia* (n. s.), *subalata;* of the Chemung group, *P. hirsuta*, *hirsuta* var. *rectispina*, *Boydii*, *rarispina*, *lachrymosa*, *lachrymosa* var. *linea*, *lachrymosa* var. *stigmata*, *speciosa*, *striatulata* (n. s.), *hystriculata*, (n. s.), *costatula* (n. s.), *costatula* var. *strigata*, *arctirostrata*, *bialveata* (n. s.), *onusta* (n. s.).

So great a number of fossils of this type in many localities, and particulary in the western part of the State, give a Carboniferous aspect to the strata; and leaving out a few forms which gradually disappear in the western extension of the formation, the paleozoic evidence might be regarded as decidedly favoring this view. The distinction, however, between Devonian and Carboniferous faunas is based as often upon geographical as chronological relations.

The species of Spirifera in the Upper Helderberg group are, *S. duodenaria, macra, raricosta* and *Grieri*, occurring both in the Schoharie grit and in the limestone above; which latter likewise contains the following species: *S. gregaria, Oweni, acuminata, macrothyris, unica* (n. s.), *disparilis, varicosa, varicosa* var., *segmenta, arctisegmenta, euruteines, euruteines* var. *fornacula, Mannii, divaricata. fimbriata.* The last named species occurs also in the Oriskany sandstone and Schoharie grit. Several of the species indicated above are known in their perfect condition only in the limestones of this age in Ohio and adjacent States of Indiana and Kentucky.

In the Hamilton group, the most abundant and widely distributed species is *Spirifera mucronata*, besides there are, *Spirifera Tullia* (n. s.), *formosa, sculptilis, ziczac, granulifera, Marcyi, medialis, medialis* var. *Eatoni, angusta, macronota, subumbona;* in the Portage group only the *Spirifera lævis*, which has much the general aspect of a Carboniferous form; in the Chemung, *S. mesacostalis, mesastrialis, disjuncta*, with its numerous synonyms and the species represented in a great variety of aspects, *alta* (n. s.), *præmatura* (n. s.).

The chapter on Spirifera is concluded with some remarks upon the geological and geographical distribution of the species of Spirifers, the hinge-structure, etc., which have already been published.*

The name Amboccelia is continued, being regarded as presenting sufficient distinction from Spirifera; and in the Hamilton group are recognized, *Ambocœlia umbonata, A. preumbona*, in the Chemung group, *A. umbonata* var. *gregaria.*

On page 263 of the volume are some observations on the genus Cyrtia of Dalman, and Cyrtina of Davidson. So long since as in 1858, Mr. Davidson, in his Introduction to the Study of the Brachiopoda, had expressed some doubts as to the value of the genus Cyrtia of Dalman; and later investigation had shown that the typical species of that genus does not differ from Spirifera. At the same time, some forms usually referred to the genus Cyrtia possess a peculiar modification of the dental plates, with a largely developed median septum and punctate structure of the shell. For these forms, Mr. Davidson has proposed the name Cyrtina. All the American species heretofore referred to Cyrtia, and which have been reëxamined, prove to belong to Cyrtina. Of these we have *C. pyramidalis* in the Niagara group, *C. Dalmani* in the Lower Helderberg group, and *C. rostrata* in the Oriskany sandstone.

Three species are described in the present volume from the rocks of New York, viz: *Cyrtina biplicata*, from the Schoharie grit; *crassa* (n. s.),

* The paper by Professor Hall alluded to on page 408 of vol. xliii of this Journal, was not a newly written article as might be inferred from the note, but as he states in introducing it, a citation from the pages of his volume IV.

from the Corniferous limestone; *Hamiltoniæ*, from the Hamilton group; and a variety of the latter from the Chemung group. A species from the Hamilton group in Iowa, *C. curvilineata* (?), is noticed.

The genus Trematospira, proposed in vol. iii, and published in the Tenth Report on the State Cabinet, is represented in the Hamilton group by two species: *T. gibbosa*, *hirsuta*.

The genus Rhynchospira is represented only by a single species, the *R. lepida*. The *R. nobilis* from the Hamilton group, formerly referred to this genus, presents some points which render its generic relations more nearly with Trematospira.

The genus Nucleospira is represented by a single species, the *N. concinna*.

Under Athyris we have the *Athyris spiriferoides*, an abundant and widely distributed form in the Hamilton group; and the *Athyris vittata*, occurring in the limestone of the Upper Helderberg group; and also in the Hamilton group of Iowa. A second species in the Hamilton group is the *Athyris cora*. In the Chemung group, we have the *Athyris angelica* and the *A.? polita*.

The genus Meristella, separated from Athyris on account of its different external characters and muscular impressions, is represented by *M. nasuta*, *scitula*, *Doris*, *Barrisi*, *Haskinsi*, *rostrata*, *Meta* (n. s.). In the Chemung group, there are a few casts of an undetermined species. The *Meristella unisulcata* of the Corniferous limestone is referred to the subgenus? Pentagonia of Cozzens, and its varieties of form illustrated. The species is of rare occurrence in the Hamilton group.

The genus Atrypa, as applied to forms strictly congeneric with *Atrypa reticularis*, embraces but few species, and these are regarded by some paleontologists as merely varieties of still fewer species. In this volume, the *Atrypa impressa* of the Schoharie grit is continued as a distinct species; although resembling the *A. reticularis* in general features, it presents a wide departure from the forms of that type in other strata; and if we are to regard these varieties as due to physical causes, the nature of the sediments, etc., then there is reason to believe that in other instances the same physical influences have produced changes which are recognized without hesitation as of specific value. The *Atrypa reticularis* in its various phases, occurs in the Corniferous limestone, the Hamilton and Chemung groups. The *Atrypa spinosa* (Hall), or *Atrypa aspera* (Schlotheim), is recognized as a very distinct and well-marked species, occurring in the Corniferous limestone, Hamilton and Chemung groups. In the Hamilton group it is more abundant and better preserved than in any other formation; and occurring in the same beds with *A. reticularis*, it never approaches that one in character; there is no difficulty in distinguishing the one from the other; and the same is true of these forms in the Chemung group. It is also observed that the same distinction between these species exists in Illinois and Iowa. The *Atrypa hystrix* of the Chemung group is likewise regarded as a distinct species, though possessing many features of an extravagant *A. spinosa*. A species of Atrypa, closely resembling the *Atrypa marginalis* of Dalman, occurs in the Corniferous limestone. This species, *Atrypa pseudomarginalis*, is of rare occurence in the rocks of New York.

A single Cœlospira occurs in the Corniferous limestone, which, so far as known, possesses no characters differing from *Cœleospira concava* of the Lower Helderberg group.

Under the Family Rhynchonellidæ, the species usually referred to the genus Rhynchonella are shown to differ from recent species referred to that genus; while at the same time the internal structure and appendages of the typical species of the genus (*R. loxia*) remain unknown or unillustrated. Under these circumstances, the name Stenocisma, proposed by Mr. Conrad in 1841, is revived, and applied to most of the rhynchonelloid forms of the rocks under consideration. Since, however, Rhynchonella has come to be so well known, and many of the species have been described under the generic designation, the name is still retained. The species of the Corniferous limestone are, *Rhynchonella* (*Stenocisma*) *Tethys*, *Billingsi* (in place of *R. thalia* of Billings, name preoccupied) *Carolina* (n. s.), *Royana* (n. s.); of the Hamilton group, *R.* (*Stenocisma*) *Horsfordi*, *Sappho*, *congregata*, *prolifica* (n. s.), *dotis* (n. s.), *carica* (n. s.); of the Chemung group, the following species are described: *Rhynchonella* (*Stenocisma*) *eximia*, *Stephani* (n. s.), *duplicata*, *contracta*, *orbicularis*, *Sappho* var.

The genus Leiorhynchus is retained for such forms as *L. limitaris* and *L. quadricostata* which present, among other distinguishing features, a division or bifurcation of the plications on the mesial fold and sinus. The species recognized as belonging to this genus are *L. limitaris*, *L. mysia* (n. s.), *L. quadricostata*, *L. multicosta*, *L. iris* (n. s.), *L. Kelloggi* (n. s.), *L. sinuatus* (n. s.), *L. mesacostalis*, *L. globuliformis*, *L. dubius* (n. s.).

Under the genus Leptocœlia, the *L. acutiplicata* is the only species recognized.

The genus Camarophoria has been observed in a single smooth species, the *C. eucharis*, from the Upper Helderberg limestones.

Some of the pentameroid forms, heretofore referred to the genus Pentamerus, are placed under new genera, on account of certain peculiarities of their internal structure.

Pentamerella includes *P. arata* (=*Pentamerus aratus*), *P. papilionensis* (=*Pentamerus papilionensis*), *P. micula* (n. s.), *P. obsolescens* (n. s.), and *P. dubia* (=*Spirifer dubius* Hall, Thirteenth Report on the State Cabinet); Gypidula includes *G. occidentalis* (=*Pentamerus occidentalis* Hall, Geol. Report of Iowa), and *G. læviuscula* (n. s.); Amphigenia is proposed to include the original *Pentamerus elongatus* of Vanuxem, which possesses characters unlike any other genus of the pentameroid family; the *A. elongata*, and a variety *undulata*. The species formerly described as *subtrigonalis* appears to be only a variety of the *A. elongata*. Rensselæria is recognized with doubt, and a single species, *R.? Johanni*, is noticed from the rocks of the age of the Upper Helderberg group in Iowa. The genus Terebratula is recognized in the following species: *T. Lens*, *T. Sullivanti* (n. s.), *T. harmonia* (n. s.), *T. Rœmingeri*, *T. Elia* (n. s.), *T. jucunda* (n. s.), *T. navicella* (n. s.), *T. simulator* (n. s.).

The genus Cryptonella includes *Cryptonella rectirostra*, *C. planirostra*, *C. Iphis* (n. s.), *C. Lincklœni*, and a doubtful form, *Cryptonella* (*Terebratula*) *eudora*, from the Chemung group; and Centronella, the *C. glansfagea*, *C. alveata*, *C. impressa* and *C. glaucia* (n. s.).

A further study of the genus Tropidoleptus has revealed certain features of internal structure, which seem to ally it with the Terebratulidæ. The *T. carinatus* is the typical species of the genus. A western form has been described under the name *T. occidens.*

The relations of the genus Vitulina are not fully established. The shell-structure is punctate, with a papillose surface, a high area on the ventral valve, with a large triangular fissure. The genus embraces a single species, the *Vitulina pustulosa.*

The volume contains critical remarks on many of the various genera, citations from some of which, Professor Hall gives in the Notice of the volume.

The labors of Professor Hall are contributing very largely to the progress of American and general Geology and Paleontology, and it is to be hoped that his engravers will do their work as rapidly as is consistent with its accuracy and beauty, that the world may speedily reap the full benefit of his extended researches.

2. *On the Paleontology of Victoria, South Australia;* by FREDERICK McCOY.—The author, after treating of the distribution and characteristics of the Post-tertiary, Tertiary, Cretaceous, and Triassic of Victoria, and pronouncing the Australian coal beds Mesozoic, makes the following observations on the Paleozoic formations of the country.

Carboniferous.—The sandstones of the Avon in Gippsland are the only traces of this formation that I can recognize in Victoria, and the only fossil I have seen from it is the *Lepidodendron*, referred to above, identical with that recognized by me many years ago from New South Wales, and which I have lately seen also from Queensland.

Devonian.—It is with great pleasure I announce the fact of my having been able satisfactorily to determine the existence of this formation also in Australia, the limestone of Buchan in Gippsland containing characteristic corals, Placodermatus fish, and abundance of the *Spirifera lævicostata*, perfectly identical with specimens from the European Devonian limestones of the Eisel.

Upper Silurian.—I have been able to recognise the Mayhill sandstones and the Wenlock rocks with certainty in many localities in Victoria. At Broadhurst Creek, for instance, the beds are filled with numbers of the *Phacops* (*Odontochilæ*) *longicaudatus* exactly as the corresponding English beds of Cheny Longville are in Shropshire; and here, as in every part of the northern hemisphere, the *Spirigera reticulata* is the commonest Brachiopod, and many others identical with species of England, Bohemia, and North America occur with it.

The Ludlow rocks are indicated by the *Orthoceras bullatum*, and a series of starfish closely representing those of the English Ludlow beds, together with a beautiful new *Homalonotus* (*H. Harrisoni* M'Coy), which I have named after the discoverer, as well as the *Graptolites Ludensis.* The *Hemithyris diodonta* Dal. is as abundant in the Mayhill sandstone of Victoria as in the corresponding English beds at Malvern, and the same appearance of oblong smooth *Pentamerus* (*P. Australis* M'Coy) mark this sandy base of the Upper Silurian in Victoria as in England and Wales, and North America.

Cambrian of Sedgwick, Lower Silurian of Murchison.—It is to this

period that I have been able without hesitation to refer the whole of the slates containing gold-quartz veins or reefs in Victoria, and all the slates containing these gold-bearing veins are identical in age and character with those of North Wales, in which the Romans worked the gold mines of Gogo Fau.

Not only are the majority of the fossil *Graptolites* found in the Welsh Llandeilo Flag, and of the corresponding Cumberland and Scotch slates, also found in those beds in Victoria, but we have in these formations the most extraordinary proof of the unexpected fact which I announced on a former occasion, that there was in the Cambrian or Lower Silurian period a nearly complete specific uniformity of the marine fauna, not only over the whole northern hemisphere, but across the tropics, extending to this remote temperate latitude of the southern hemisphere.

In the slates of the goldfields the principal fossils are *Graptolites*, and, what is very extraordinary, I have here identified specifically nearly the whole of the series of remarkable compound *Graptolites* first made known from the similar slates of Canada by the researches of Professor Hall. Many of the species have not yet been recognised in any but the Canadian localities in the northern hemisphere, and to find nearly the whole series here is most interesting, as their powers of locomotion could only be exercised in the short ovarian and free stage, so that, except on the supposition of a uniform marine fauna at this earliest zoological period of the earth's history, we could scarcely account for this width of distribution, and still less so of the littoral or shallow-water mollusca which accompany them in other beds. The *Diplograpsus mucronatus* Hall, so common in the Utica slates of New York, I find in equal abundance here in the slates of Bendigo or Sandhurst, and with it abundance of the *D. quadrangularis* M'Coy, completely identical with those I described many years ago from the slates of Dumfriesshire. The *Diplograpsus pristis* (His. sp.), also occurs in these same slates, mixed with the others, as in Sweden, Bohemia, and Scotland, but in certain different sandy beds it covers the whole of the planes of deposition in millions, to the exclusion of everything else, exactly as it does in certain beds of the English Caradoc sandstone near Church Stretton. In some localities these are replaced by great numbers of the Bohemian *Diplograpsus palmeus* Barrande, on the upper end of many specimens of which I find a large smooth pear-shaped or heart-shaped appendage, which I believe to be an ovarian vesicle. I should remark that I have observed exactly the same appendage (bearing out, I think, the idea which I have supported formerly on other grounds,* of the affinity of the *Graptolites* with the *Hydroida*) in specimens of this species from the slates of the typical locality in Bohemia, when carrying out the direct careful comparisons of specimens of species, which I state to be identical in Victoria and other countries; so the frequent observation of this apparent ovicell in the Victorian specimens does not at all affect the identity of this species with that of the basin of Bohemia, of which there can be no doubt. The *D. ramosus* Hall is also in our slates identical with those of the Utica slate of New York. Of the group of compound Canadian *Graptolites*, the commonest in the Victorian goldfield slates of many localities is the

* British Palæozoic Rocks and Fossils.

Didymograpsus caduceus Salt., first described from the Quebec slates. In many localities the specimens of this species are as small as the first described Canadian ones, but in others they acquire a greatly increased size, occasionally twice the length and nearly three times the width, and the angle of divarication of the two branches varies from 5° to 70°.

This is usually accompanied by the *D. serratulus* Hall, identical with those of New York slates, and generally also by the very large Canadian *D. bryonoides* Hall, which it is possible may be hereafter found to be the perfect development of my *G. latus*. The *D. nitidus* Hall is more rare, but perfectly identical with the Canadian types. The *Graptolites gracilis* Hall, identical with the New York and Canadian species, is one of the rare compound forms. The curious radiating compound forms, which created so much astonishment when published first by Professor Hall in his Decades of the paleontology of this part of Sir H. Logan's geological survey of Canada, I find in just as great abundance in the slates of the same age in Victoria. *D. octobrachiatus*, *D. quadribrachiatus*, and *D. Logani* Hall, are, especially the latter, not uncommon in many of the goldfield localities. The curious Canadian quadrifid graptolite, named *Phyllograptus Typus* by Hall, is one of our most abundant Australian Graptolites; but, although sometimes upwards of an inch in length, small specimens, I find, on comparison with Swedish specimens of the *G. Folium* of Hisinger, are perfectly identical therewith; and further, on carefully comparing Bohemian specimens of the *G. ovatus* of Barrande with the Swedish *G. folium*, I have no doubt they belong to one variable species, and are identical with the smaller examples of the Australian and Canadian species; and further, that the European specimens are truly quadrifoliate, like Hall's *Phyllograptus;* and in this way the difference in the different descriptions, as to the width of the midrib, becomes intelligible.

As a general rule, the graptolite slates in every part of the world contain no other fossils. I many years ago discovered in Wales, near Builth, the only shell I ever heard of in graptolite slates (the *Siphonotreta micula* M'Coy), and I was greatly surprised to recognize it also in Victoria, in the Deep Creek section. The crustacean genus *Hymenocaris* is represented by a new species, *H. Salteri* M'Coy, found in most of the graptolite slate localities.

In a different set of sandy, marly, and mud-stone beds—as at Woori Yallock, Yarra—we find an extensive series of the genera and many of the species of corals, trilobites, and mollusca of the "Bala beds" of North Wales; species of *Favosites*,* *Palæopora*, *Calymene*, *Phacops*, *Beyrichia*, *Strophomena*, *Leptagonia depressa*, *Spirigera reticularis*, *Orthis elegantula*, the characteristic little genus *Cucullella*, *Murchisonia*, *Cornularia*, &c.; and some species new, and some identical with British ones, forming a group so completely reproducing the well known Bala beds as to afford a second case in support of the view of the general specific identity of the marine fauna over both hemispheres of the whole world in the earliest paleozoic times.

* It is worthy of remark, that as on the continent of Europe the Devonian genus *Pleurodictyun* has now been found in Silurian strata, so in those beds in Victoria I find a new species (*P. megastoma*, M'Coy), with cells half an inch in diameter.

It is curious that I have not yet seen any trace of the genus *Trinucleus* in Australian beds, nor *Ampyx*, while all the above-mentioned genera of Trilobites, with *Acidaspis*, *Chirurus*, &c., are well marked.

I can scarcely close this part of the subject without drawing attention to the curious confirmation offered in Victorian geology of the view of Professor Sedgwick and myself, that there was a real systematic line of division between the Upper Silurian and the Cambrian and Lower Silurian, at the base of the Mayhill sandstone, and over the Caradoc sandstone—the Mayhill sandstone which we first defined and demonstrated to have Upper Silurian fossils only, and the true Caradoc sandstone full exclusively of Lower Silurian or Cambrian types; the previous confusion of these two sandstones, from the mingling erroneously of the fossils in collections, having given Sir Roderick Murchison the erroneous impression that his Upper and Lower Silurian groups of fossils (the distinctness of which he himself was the first to point out) were mixed together in the Caradoc sandstone, and that consequently the Bala beds, identical in fossils with those of the Caradoc beds (although formerly recognized by him as the type of the Cambrian system), could not be separated paleontologically from the Upper Silurian group. The Mayhill sandstone was one of the first formations I recognized on landing near Melbourne, with the usual Upper Silurian fossils; and it is now found here, as in Wales, to be slightly unconformable to the Cambrian or Lower Silurian, forming the obvious base of the former, and totally distinct in fossils from the latter.

3. *Note by F. B. Meek to his Review of Prof. Geinitz in regard to Nebraska fossils.* (See p. 170).—Since writing the remarks on the Nebraska fossils investigated by Prof. Geinitz, an extensive collection of specimens obtained at Nebraska City by Dr. Hayden and myself, during the progress of the geological survey of that state (now under his charge) and placed in my hands for investigation, enables me to give the following additional information.

On page 182, I expressed the opinion, from the examination of some rather imperfect specimens shown to me by Dr. White from Iowa, that the species referred by Prof. Geinitz to the so-called *Avicula pinnæformis*, is not only specifically distinct from that shell, but that it probably belonged to the distinct genus *Pinna*. A careful examination of a fine series of much better specimens from Nebraska City confirms my first conclusion in regard to its being a distinct species, and at the same time leads to the conclusion that it is an *Aviculopinna*, since its beaks are slightly removed from the extreme point of the shell, so as to leave a very small lobe in front, best seen in internal casts. It differs, however, specifically from the European *A. pinniformis*, not only in never attaining one-fourth as large a size, in its more uniform outline, and its much more nearly terminal beaks, but in being without any *traces* of radiating striæ, while its concentric markings differ in being strong, regularly disposed, rather distantly separated and abruptly elevated lines or lamellæ, unconnected with concentric wrinkles on any part of the valves; instead of fine crowded striæ, gathered into wrinkles on the ventral region. It is also provided on the upper half, with two or three large, very obscure radiating folds not seen on *A. pinniformis*, while its posterior margin also differs in being slightly sinuous just under the extremity of the hinge.

For this species I would propose the name *Aviculopinna Americana*. As might be expected, the very thin substance of this shell is seen under the microscope to have a prismatic structure, like that of other types of the *Aviculidæ*.

I avail myself of this opportunity to correct a few typographical errors that occur in my remarks on the Nebraska fossils in this number of the Journal.

Page 173, fifth line from top, for "respecting" read representing. Page 177, seventeenth line from top, for "thus far" read this far. Page 180, twenty-second line from bottom, for "they are," read it is. Page 184, sixth line from top, strike out the ? after *Rhynchonella*.

4. *Note on the Corundophilite of Chester, Mass.*—In a note on page 258 the writer has alluded to observations on the optical characters of the Chester chlorite made by Mr. Descloizeaux. Mr. Descloizeaux communicated his results to the writer in a letter dated Paris, Jan. 29, 1866, or a year and a half since. They are as follows.

Corundophilite is a clinochlore, in macled plates or crystals. The divergence of the axes is very variable, they being sometimes united, and at others widely separated. The bisectrix is *positive*, and distinctly inclined to the plane of cleavage or the surface of the plates. In one good plate I found 2E (or angle of divergence observed in the air) $=65°$ for white light at 22° C. On heating to 200° C., the angle was increased from 3 to 4 degrees, a characteristic distinguishing clinochlore from pennine, which is always insensible to heat. The dispersion of the optical axes is quite distinct and $\rho<\upsilon$. The hyperbolas are bordered by red interiorly and green exteriorly.

5. *Note on the optical characters of different micaceous minerals called Margarite;* by Mr. DesCloizeaux. (From a letter to J. D. Dana, dated Paris, August 15, 1867).—(1.) In 1847 I received from the vicinity of Sterzing, a foliated mineral having the plates a little concave, of white color and pearly luster, and well named *perl-glimmer*, which has the optical axes distinctly united.

(2.) The small specimen sent me recently by Mr. Dana as the original margarite is identical with one which had been sent me after 1848; it is in white laminæ mixed with some green clinochlore, and was regarded at that time as chloritoid. The laminæ are very much macled, and the divergence of the optical axes is accordingly very variable. I have found for the red ray, at 20° C. with

my specimen	$2E=126° 24'$;	in another plate, $=117° 30'$.
Mr. Dana's specimen	$2E=109° 32'$; " " "	$128° 38'$.

The dispersion is very feeble, and it is rendered quite indeterminable by the numerous interlacings of the laminæ. The plane of the optical axes appears to be parallel to the longer diagonal. [This is the margarite of p. 259.]

The clinochlore mixed with the margarite is macled, with distinct dispersion ($\rho<\upsilon$), and with strong double refraction. A plate gave me

$2E=60° 48'$ for the yellow ray.

(3.) In 1863 I received from Rammelsberg, under the name of *Barytglimmer* [the Œllacherite of p. 256] a so-called margarite from Pfitsch, which is white and pearly, and has been analyzed by Œllacher. The

plates are very transparent, the double refraction strong, the dispersion feeble with $\rho > v$, and orientation of the optical axes uncertain because of the irregular contour of the laminæ. I have found, at 20° C.

$2E = 79° 21'$ for the red ray; $2E = 78° 45'$ for the blue,

angles which correspond with those of ordinary potash mica.

6. *Eozoon Canadense in Finland.*—Prof. Pusirevski reports the occurrence of the Eozoon Canadense in limestone at Hopunwara in Finland. A lower and upper system of schistose metamorphic rocks have been distinguished. In the lower division of the upper system, at Pusunssari and Hopunwara near Pitkäranda occurs a limestone with serpentine, and the serpentine affords small nodules consisting of parallel layers which have the structure of the Eozoon. The facts are stated to prove that a large part of the rocks of Finland are Laurentian, and that the upper and lower systems probably correspond to the upper and lower groups of Canada.—*Bull. Acad. St. Petersbourg*, x, 151.

7. *Geological Observations in Colorado.* (Colorado Transcript, July 24, 1867.)—The late railroad surveys on Dry and Boulder creeks, St. Vrain, Big Thompson and Cache-a-la-Poudre rivers, and on the South Platte, under Capt. E. L. Berthoud, have shown that the Cretaceous strata on the east slope of the Rocky Mountains, extend eastward from the mountains at least four hundred and seventy-five miles; that in the upper beds, extending some seventy-five miles from the Rocky Mountains, coal of good quality can be found in large fields, which near the mountains in Jefferson county are covered on its west border by almost horizontal Tertiary beds, and through which extensive outcrops of Cretaceous coal occur.

8. *Geological Survey of Nebraska.*—By appointment from the General Government, the geological survey of Nebraska has just been commenced under the direction of Professor F. V. Hayden. Dr. Hayden is in his old familiar field, where he has explored in former years with great success, and we may expect very valuable results from his investigations. The experienced paleontologist, Mr. F. B. Meek, is associated with him in the work. The territory of Nebraska lies directly west of the state of Iowa, the survey of which state is going rapidly forward under Dr. C. A. White, its able state geologist; and this again directly west of Illinois, whose geological survey under Dr. Worthen has already made great progress, as shown in the admirable volumes recently published. The Reports of these regions when completed, will extend our knowledge of the geology of the continent on this side of the Rocky Mountains to 104° W. It is to be regretted, however, that the great and rich states of Ohio and Indiana yet remain but very imperfectly explored.

III. BOTANY.

1. *Manual of the Botany of the Northern United States, including the district East of the Mississippi and North of North Carolina and Tennessee, arranged according to the natural system;* by ASA GRAY, Fisher Professor of Natural History in Harvard University. Fifth edition, with twenty plates illustrating the Sedges, Grasses, Ferns, etc. New York: Ivison, Phinney, Blakeman & Co. Chicago: S. C. Griggs & Co. 1867, 8vo, pp. 701.—The former editions of this Manual have been duly noticed in this Journal. The first edition was published in 1848, and was at once accepted as the standard Flora of the region it embraced.

The work was entirely rewritten for the edition of 1856, and was revised upon the stereotype plates, some pages also being added, for the third edition (1862), and for the fourth (1863). The fifth edition has been mostly rewritten, several month's labor having been expended upon it.

The *Garden Botany* is excluded from this edition, but will be incorporated into a separate, more elementary work entitled *Field, Forest,* and *Garden Botany.* The *Mosses* and *Liverworts,* also, which were contributed to the previous editions by Mr. Sullivant, are now omitted, but the hope is expressed that these orders, together with the *Lichenes,* by Prof. Tuckerman, and perhaps the remaining orders of Cellular Cryptogamia, may before very long be published in a supplementary volume.

To the fourteen plates at the end of the volume, illustrating the genera of Grasses and Ferns, are now added six new ones, from original drawings by Sprague, to show the structure of the genera of Cyperaceæ. By the help of these accurately drawn figures the student will be able to identify easily the genus of any native or introduced plant belonging to these somewhat difficult orders.

While the general plan of the work is otherwise unchanged, a comparison of this volume with its predecessor shows that the learned author has taken new views of several natural orders, and that the generic and specific descriptions generally have been studied anew, and most faithfully compared with the plants as they exist in nature.

Among the changes in the natural orders to be particularly noticed is the uniting of *Nelumboneæ* and *Cabombaceæ* with *Nymphæaceæ.* This had already been done by Bentham & Hooker, and indeed we find *Nelumboneæ* made a tribe of *Nymphæaceæ* in DeCandolle's *Systema Vegetabilium.* But why not keep the name *Nelumbo* as originally written by Adanson in 1763, and adopted by Gærtner in 1788, a year before it was changed to *Nelumbium* by Jussieu? It would then accord with *Negundo.*

Another noticeable change is the restoration of *Tropæolum, Impatiens* and *Oxalis* to *Geraniaceæ,* in which order they were placed as "*Genera Geraniis affinia*" by its founder Jussieu. In the same order Dr. Gray has placed *Flœrkea* also, in the whole arrangement following pretty closely the views of Bentham & Hooker. The same authors had already included *Ribes* as well as *Parnassia* in *Saxifragaceæ.* The clustered staminodia of *Parnassia* are perhaps peculiar to the genus, but there are single staminodia or glands alternate with the stamens of *Francoa* and *Tetilla,* and the multifid lobes of the disk in *Brexia* is perhaps somewhat similar. Nor does *Ribes* alone produce berries, for they occur in several genera of *Escallonieæ.*

Haloragaceæ is separated from *Onagraceæ,* the points of difference being numerous and well marked. *Loganiaceæ* is recognized as a natural order and is placed next after *Gentianaceæ. Liliaceæ* is much extended, *Trillideæ* and *Melanthieæ* being regarded as tribes, the genera *Prosartes* and *Streptopus* placed in *Asparagineæ,* and *Narthecium* in *Lilieæ.* Some such consolidation of orders in the lilial alliance has seemed inevitable ever since it was shown by Dr. A. W. Chapman that the anthers of *Lilium* itself are extrorse in the bud.

The alterations in generic nomenclature and the uniting or dividing of genera are not very numerous, and every such change was apparently demanded by the progress of botanical science.

Atragene is reunited with *Clematis*, and *Pulsatilla* with *Anemone*. *Iodanthus* and *Turritis* go into *Arabis*, and *Arenaria* now includes *Alsine*, *Mœhringia* and *Ammadenia* (*Honkenya*). *Sanguisorba* is referred to *Poterium*, the characters of *flowers perfect*, *stamens few*, *carpel single*, *and seeds mostly smooth* not being constant, and the habit being the same in both. The restoration of the Linnæan genus *Houstonia* is most welcome, and we may now call the little *Bluets* by the name they bore when we first knew and admired this pretty flower. The Linnæan name *Ruellia* replaces the later one of Nees, *Dipteracanthus;* and *Stylisma* is referred to *Bonamia*, the characters of *styles somewhat less united* and *stamens less exserted* not justifying the separation of the American from the Madagascar species. *Benzoin* of Nees becomes *Lindera* of Thunberg, and the old genus *Habenaria* is restored to North American botany, for *Gymnadenia* and *Platanthera* both yield their places as distinct genera, Dr. Gray here returning to the view which he proposed in this Journal, in 1840.

A few specific names are altered, especially where older but less known names have been recently identified with well known species, as for instance *Ranunculus multifidus* (Pursh, 1814,) is substituted for *R. Purshii* (Richards, 1823), or where an American plant is proved to be identical with an older European species, as is *Viola Muhlenbergii* with *V. canina*. Not a few plants which were utterly unknown when the fourth edition of the Manual was published, in 1864, are now for the first time made known to science, and many more which were known to inhabit adjacent, or sometimes distant regions have been recently detected within our limits. A new *Polygala*, an *Aster*, a *Lobelia*, a *Pyrola*, two *Orchids* and two species of *Isoetes* are among the former, and the latter class includes a *Stellaria*, a *Parnassia*, another *Aster*, *Calluna vulgaris*, an *Ilex*, nearly a score of *Carices*, and several *Ferns*. In 1856 the indigenous Flowering plants and Acrogens known to inhabit the region covered by this Manual amounted to 2166, which number has now been increased by the zeal and industry of North American botanists to 2357, as is shown by a hasty count of the distinct and truly indigenous species described in the present volume.

The various Analytical keys have been prepared anew, and evidently with the greatest carefulness, the distinctions being based upon the important characters of the plants, rather than upon their trivial peculiarities, so that to a student who has thoroughly studied Physiological Botany, as taught for instance in Gray's Lessons, these Analytical keys will not only open an easy way to find the name of an unknown plant, but will also reveal much of the true relations of the plant to the whole Vegetable Kingdom.

In certain orders and genera the author has had the aid of collaborators who have devoted special attention to their several departments, among whom Dr. Engelmann takes the lead: all such assistance is amply acknowledged in the proper place.

As to thorough scientific arrangement, correct nomenclature, and accuracy and clearness of the definitions, this Flora is almost or quite unrivalled, there being no American, and few European works of the kind, which could bear comparison with it; and it will be well for the cause of American learning if this Flora, suited alike to the needs of

accomplished botanists and unpracticed students, shall displace works which are wholly rejected by the former, and are used by the latter only to their own injury and confusion. D. C. E.

IV. ASTRONOMY.

1. *Recent Observations and Remarks of Hofrath Schwabe regarding Sun-spots and other Solar Phenomena.* Communicated by W. De la Rue, B. Stewart, and B. Loewy.—About two months ago Hofrath Schwabe called our attention to certain phenomena on the surface of the Sun, which he had noticed since last December, and which he recollected to have occurred before, but only at the time of a minimum in the number of Sun-spots. The phenomena are:—1st. *A total absence of faculæ or faculous matter.* 2nd. *Absence of the usually observed scars, pores, and similar appearances.* 3rd. *An equal brightness of the whole surface, the limb being as luminous as the center.*

Hofrath Schwabe desired us to go over his observations, which are at present at Kew Observatory, to extract similar facts formerly noticed, and to inform him whether some of these phenomena had also been observed in this country.

The observations were carefully scanned; and it was noticed that the phenomena occur only in years of minimum spot-frequency. The extracts, which we append, and which might have been multiplied, are quite sufficient to show the regularity of their recurrence, and also that the year 1833 was particularly characterized by the frequency of observations of them.

We also applied to the Rev. F. Howlett, whose well-known exquisite delineations of Sun-spots and faculæ gave us the best promise of learning something more relating to delicate changes on the surface of the Sun; but unfortunately Mr. Howlett's impaired health has obliged him to withdraw almost wholly from his usual application to Sun observations during the period in question. He however states in his answer, that "he had certainly noticed how uniformly bright the Sun's surface has been of late, in connection with an almost total absence of faculæ."

We think it right to state (without expressing our own opinion in the matter) that Hofrath Schwabe thinks he has noticed a connexion between Sun-spots and meteoric showers. He says in his last letter, "The minimum of spot-frequency coincides remarkably with the recurrence of meteoric showers, the period of rotation of which, viz., 33·2 years, agrees with a larger period of the sun-spots. In 1833 there was an extreme scarcity of spots (only 33 very small groups being observed), and in 1866–67, after 33 years the phenomenon repeats itself. From the 1st January until to-day, June 8th, I have only observed 6 small groups, and out of 133 days of observation, there were 100 without spots. In the year 1848, which is the middle of the 33·2 years period, there was a maximum of spots. If the 33 years' period should be established by future observations, then a maximum of meteoric showers would always occur after three years of the usual Sun-spot periods. Whether this periodicity existed before, I cannot decide, but there appears to have been a minimum of Sun-spots in 1798·5, and a maximum in 1816·8."

We are at present engaged in determining a curve of spot-frequency during the last forty years, founded, not on the *number of observed groups*,

but on the *area of spotted surface*, as observed by Hofrath Schwabe; and we hope that by this means the periodicity will be represented with greater precision than before, and also that more light will be then thrown on the whole subject; but in the meantime we would call the attention of all observers to the fact, that in the present state of our inquiries into the physical nature of the Sun and into the connexion of cosmical phenomena, even the most delicate changes observed deserve great attention, and that nothing should be overlooked by those who take an active interest in this problem.—*Not. Roy. Astron. Soc.*, xxvii, 286.

2. *On a Meteor of July 18th, 1867;* by DANIEL KIRKWOOD, (Editorial correspondence dated Canonsburg, Pa., August 5th, 1867).—Mr. J. K. Larimore, A. B., has furnished me the following account of a meteor seen by himself, at Salem, Westmoreland County, Pennsylvania, on the 18th of July, 1867.

The time of observation was about $7^h\ 30^m$ P. M.—almost exactly at sunset. The meteor seemed to have originated in the S.E. quarter of the heavens, and it disappeared in the N.E. When first seen its elevation was about 40°, and it continued visible from four to five seconds. Its apparent diameter was estimated at one-fourth that of the moon, and it had a train three or four degrees in length.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Researches on Gun-cotton.—Second memoir. On the Stability of Gun-cotton;* by F. A. ABEL, F.R.S., V.P.C.S. (From the Phil. Mag., IV, xxxiii, 545, July, 1867, Supplement.)—The results of the many observations which had been instituted prior to 1860 upon the behavior of gun-cotton when exposed to diffused or strong daylight, or to heat, although they agree generally with those of the most recent investigations on the subject, as far as relates to the nature of the products obtained at different stages of its decomposition, cannot be regarded as having a direct bearing upon the question of the stability of gun-cotton produced by strictly pursuing the system of manufacture prescribed by von Lenk, inasmuch as it has been shown that the products formerly experimented upon by different chemists varied very considerably in composition.

The investigations recently published by Pélouze and Maury* on the composition of gun-cotton, and the influence exerted by light and heat upon its stability, are described as having been conducted with gun-cotton prepared according to von Lenk's system. The general conclusion arrived at by those chemists with reference to the latter branch of the subject was to the effect that the material is susceptible of spontaneous decomposition, under conditions which may possibly be fulfilled in its storage and application to technical and warlike purposes; and the inference is drawn, partly from the results of earlier investigators, and partly from the exceptional behavior of one or two specimens, that gun-cotton is liable to explode spontaneously at very low temperatures when stored in considerable quantities.

It has been shown, in the memoir on the Manufacture and Composition of Gun-cotton, published last year,† that modifications in the pro-

* Comptes Rendus.

† Trans. Royal Society. For abstract see Phil. Mag., IV, xxxii, 145.

cesses of conversion and purification, which appear at first sight of very trifling nature, exert most important influences upon the composition and purity of the product. Gun-cotton of quite exceptional character has been discovered, in several instances, among samples received from Hirtenberg and among the first supplies obtained from Stowmarket; other exceptional products have also been produced by purposely modifying, in several ways, the system of manufacture as pursued at Waltham Abbey. The very considerable difference exhibited between some of these and the ordinary products in their behavior under equal conditions of exposure to heat and light, affords good grounds for the belief that the attainment of certain exceptional results, upon which the conclusions of Pélouze and Maury's report condemnatory of gun-cotton have been principally founded, are to be ascribed to such variations in the nature of the material operated upon.

Very numerous and extensive experiments and observations have been carried on during the last four years at Woolwich, both with small and large quantities of gun-cotton, for the purpose of completely investigating the conditions by which the stability of this substance, when under the influence of light and heat, may be modified, and with the view of ascertaining whether results recently arrived at in France apply to gun-cotton as manufactured in this country.

The principal points which have been established by the results arrived at in these investigations may be summed up as follows:—

(1.) Gun-cotton produced from properly purified cotton, according to the directions given by von Lenk, may be exposed to diffused daylight, either in the open air or in closed vessels, for very long periods without undergoing any change. The preservation of the material for $3\frac{1}{2}$ years under those conditions has been perfect.

(2.) Long-continued exposure of the substance in a condition of ordinary dryness to strong daylight and sunlight produces a very gradual change in gun-cotton of the description defined above; and therefore the statements which have been published regarding the very rapid decomposition of gun-cotton when exposed to the sunlight do not apply to the nearly pure trinitrocellulose obtained by strictly following the system of manufacture now adopted.

(3.) If gun-cotton in closed vessels is left for protracted periods exposed to strong daylight or sunlight in a damp or moist condition, it is affected to a somewhat greater extent; but even under these circumstances the change produced in the gun-cotton by several months' exposure is of a very trifling nature.

(4.) Gun-cotton which is exposed to sunlight until a faint acid reaction has become developed, and is then immediately afterward packed into boxes which are tightly closed, does not undergo any change during subsequent storage for long periods. (The present experience on this head extends over $3\frac{1}{2}$ years.)

(5.) Gun-cotton prepared and purified according to the prescribed system, and stored in the ordinary dry condition, does not furnish any indication of alteration, beyond the development, shortly after it is first packed, of a slight peculiar odor and the power of gradually imparting to litmus, when packed with it, a pinkish tinge.

(6.) The influence exercised upon the stability of gun-cotton of average quality, as obtained by strict adherence to von Lenk's system of manufacture, by prolonged exposure to temperatures considerably exceeding those which are experienced in tropical climates, is very trifling in comparison with the results recently published by Continental experimenters relating to the effects of heat upon gun-cotton; and it may be so perfectly counteracted by very simple means, which in no way interfere with the essential qualities of the material, that the storage and transport of gun-cotton presents no greater danger, and is, under some circumstances, attended with much less risk of accident than is the case with gunpowder.

(7.) Perfectly pure gun-cotton, or trinitrocellulose, resists to a remarkable extent the destructive effects of prolonged exposure to temperatures even approaching 100° C.; and the lower nitro-products of cellulose (soluble gun-cotton) are at any rate not more prone to alteration when pure. The incomplete conversion of cotton into the most explosive products does, therefore, not of necessity result in the production of a less perfectly permanent compound than that obtained by the most perfect action of the acid mixture.

(8.) But all ordinary products of manufacture contain small proportions of organic (nitrogenized) impurities of comparatively unstable properties which have been formed by the action of nitric acid upon foreign matters retained by the cotton fiber, and which are not completely separated by the ordinary, or even a more searching process of purification.

It is the presence of this class of impurity in gun-cotton which first gives rise to the development of free acid when the substance is exposed to the action of heat; and it is the acid thus generated which eventually exerts a destructive action upon the cellulose-products, and thus establishes decomposition which heat materially accelerates. If this small quantity of acid developed from the impurity in question be neutralized as it becomes nascent, no injurious action upon the gun-cotton results, and a great promoting cause of the decomposition of gun-cotton by heat is removed. This result is readily obtained by uniformly distributing through gun-cotton a small proportion of a carbonate,—the sodic carbonate, applied in the form of solution, being best adapted to this purpose.

(9.) The introduction into the finished gun-cotton of one per cent of sodic carbonate affords to the material the power of resisting any serious change, even when exposed to such elevated temperatures as would induce some decomposition in the perfectly pure cellulose-products. That proportion affords, therefore, security to gun-cotton against any destructive effects of the highest temperatures to which it is likely to be exposed even under very exceptional climatic conditions. The only influences which the addition of that amount of carbonate to gun-cotton might exert upon its properties as an explosive would consist in a trifling addition to the small amount of smoke attending its combustion, and in a slight retardation of its explosion, neither of which could be regarded as results detrimental to the probable value of the material.

(10.) Water acts as a most perfect protection to gun-cotton (except when it is exposed for long periods to sunlight), even under extremely severe conditions of exposure to heat. An atmosphere saturated with

aqueous vapor suffices to protect it from change at elevated temperatures; and wet or damp gun-cotton may be exposed for long periods in confined spaces to 100° C. without sustaining any change.

Actual immersion in water is not necessary for the most perfect preservation of gun-cotton; the material, if only damp to the touch, sustains not the smallest change, even if closely packed in large quantities. The organic impurities which doubtless give rise to the very slight development of acid observed when gun-cotton is closely packed in the dry condition, appear to be equally protected by the water; for damp or wet gun-cotton, which has been preserved for three years, has not exhibited the faintest acidity. If as much water as possible be expelled from wet gun-cotton by the centrifugal extractor, it is obtained in a condition in which, though only damp to the touch, it is perfectly non-explosive; the water thus left in the material is sufficient to act as a perfect protection, and consequently also to guard against all risk of accident. It is therefore in this condition that all reserved stores of the substance should be preserved, or that it should be transported in large quantities to very distant places. If the proper proportion of sodic carbonate be dissolved in the water with which the gun-cotton is originally saturated for the purpose of obtaining it in this non-explosive form, the material, whenever it is dried for conversion into cartridges, or employment in other ways, will contain the alkaline matter required for its safe storage and use in the dry condition in all climates.

2. *Scientific party for Sitka.*—A scientific party left San Francisco July 21st on the steam cutter *Lincoln* for Alaska. This party has been organized under the direction of Prof. Peirce, Superintendent of the U. S. Coast Survey, and is conducted by George Davidson, Assistant U. S. Coast Survey, as chief. With him are associated A. T. Mosman, Astronomer; Geo. Farquhar, hydrographer; with whom is associated I. Forney, as aid;—Hamel, engineer; Dr. Albert Kellogg, botanist; W. G. W. Harford, Conchologist; T. A. Blake, Geologist, and John Tidal, observer. The first business will be a geographical reconnoissance of the Coast.—*San Francisco Bulletin.*

3. *American Association for the Advancement of Science.*—The meeting of the Association at Burlington is just now closing as we put the last pages of this number to the press. We have to defer a notice of the proceedings to our November number.

OBITUARY.

Jeremiah Day.—Jeremiah Day, the venerable ex-President of Yale College, died at his residence in this city, on Thursday evening, August 22.

President Day had reached, on the 3d of the present month, the age of ninety-four years. His death will naturally occasion little surprise; yet the announcement of it will affect the hearts of thousands of pupils and friends who have long looked up to him with profound veneration and esteem.

He was born in New Preston, Conn., August 3, 1773. He first entered Yale College in 1789, seventy-eight years ago. Owing to ill health, he was absent from College for a considerable time, and did not graduate until 1795, the year when Dr. Dwight became president. The first official act of this eminent man was to preside at the Commencement at

which the class of which President Day was a member was graduated. Mr. Day succeeded Dr. Dwight as teacher of the school which the latter had conducted at Greenfield, and remained there until his election as tutor in Williams College. In 1798 he became tutor at Yale, and while holding this office pursued theological studies and preached as a candidate for the ministry. In 1801 he was elected to the professorship of Mathematics and Natural Philosophy. His health at this period was feeble, and neither he nor his friends anticipated for him a long continuance of life. He was able, however, to enter on the duties of his new station in 1803, which he continued to discharge until 1817, when, on the decease of Dr. Dwight he was chosen president, and continued in this office until his resignation in 1846. He fulfilled the duties of the presidency with distinguished success and with the entire approbation of the college and of the public. He remained a member of the corporation until the last commencement, when, in consequence of his "diminishing powers of life,"—to quote his own apt phraseology—he severed this last link of official connection with the college which he had served so long and faithfully. President Day was the author of a series of mathematical text-books which have passed through numerous editions. He also published two metaphysical treatises on the subject of the Will, besides various papers in the New Englander and other periodicals. In 1810 he published a brief paper, in the Memoirs of the Connecticut Academy of Sciences, on the origin of meteorites, called out by the recent fall (in 1807) of the meteorite of Weston, in which he took the ground, that they were cometary bodies of the solar system.

President Day possessed a strong understanding, and was more remarkable for the balance and symmetry of his powers than for the extraordinary development of any one of them. He was an exact thinker and a clear reasoner. His great moral and religious excellence has been universally recognized from his youth up. None who knew President Day will feel that there is any exaggeration in applying to him the sentence: "Mark the perfect man and behold the upright, for the end of that man is peace."

He was the last survivor of the colleagues whom President Dwight selected and drew around him, and whose united labors first gave celebrity to Yale College. Kingsley, Silliman, and now Day, the oldest of the three, are gone; but they deserve to be perpetually honored by all who feel an interest in the institution to which their labors were devoted.

F.

E. J. Pickett.—Edwin Judson Pickett was born near Rochester, N. Y., in 1830, and from early childhood that city was his home. Graduating from the University of Rochester in 1856, he afterward devoted his life to teaching and to the study of the natural sciences, geology finally becoming his favorite pursuit. In 1861, he received an appointment in the Institute at Mexico, N. Y., and in 1864, was appointed to the Professorship of Natural Science in the People's College at Havana, N. Y. After the failure of that institution, he took charge of a flourishing Collegiate Institute at Attica, Ind., and continued in the work until consumption, which had long before undermined his health, compelled him to seek his home and there await its lingering termination. He died on the 13th of October, 1866.

Mr. Pickett was of an exceedingly modest and retiring disposition, and did not seek society; but none who met him could fail to love him. An enthusiast in science, an indefatigable worker in whatever he put his hand to, and also an earnest Christian, his loss is a great one. With so few devotees, and so much work to be done, science can ill afford to spare one such. B.

FARADAY.—The telegraph brings the announcement that the eminent philosopher, Faraday, died on the 27th of August, in his 73d year.

VI. MISCELLANEOUS BIBLIOGRAPHY.

1. *Annals of the Astronomical Observatory of Harvard College.* Vol. II, Part II, and Vol. V. Cambridge, 1867. 4to, pp. 263, 215.—Part I of vol. II (Observations on Saturn) was published in 1857. Part II, just issued, contains a Zone Catalogue of 4484 stars situated between 0° 20′ and 0° 40′ north declination, observed during the years 1854–55, with the Cambridge equatorial. A similar catalogue of 550 stars (between 0° 0′ and 0° 20′ N. dec.) constitutes Part II of vol. i, where may be found the introductory matter pertaining to both series of zone observations. Two other like series still remain unpublished. These catalogues extend to stars of the 13th magnitude, and afford ample evidence of the ability and zeal with which the two Bonds, father and son, were accustomed to employ the great telescope which constitutes the principal instrument of the Cambridge Observatory.

The other volume just issued, the fifth of the series, gives the results of the latest labors of Prof. G. P. Bond—his elaborate observations on the great nebula in Orion. These observations were undertaken in 1857, but being interrupted, in 1858, by the work due to the great comet of that year, and by other causes, were resumed after the publication of the volume on the comet, and prosecuted as the failing strength of Mr. Bond would permit, nearly to the time of his death, in 1865. The splendid engraving of the nebula, which accompanies this volume, was executed under his eye, and the impressions taken in 1864. The observations were also reduced, for the most part, before the death of Mr. Bond, and the materials left in such a state of forwardness that, with the careful editorship of Prof. Safford, so long associated with Prof. Bond in the observatory, the work is now presented to astronomers, if not in as complete a form as it would have been had the life of the author been longer spared, yet in such a shape as to render it a noble contribution to astronomical science, and greatly enhance the already high reputation of its lamented author.

The volume is in the style of that on Donati's Comet, and the engravings are by the same artist. Besides the engraving, already referred to, from the drawing of Prof. G. P. Bond, it contains another representing the nebula as seen by Prof. W. C. Bond, with the same telescope, in 1848, and also two charts of the stars in and near the nebula, as laid down by the same author. The principal work of Prof. G. P. Bond consisted in determining, by differential observations, the positions with reference to θ Orionis of all stars visible with the Cambridge equatorial within an area extending 1° 30′ on each side of this star in declination,

and $2^m\ 15^s$ each way in right ascension. This area of 3·36 square degrees embraces 1000 stars, or 298 to a square degree.

The different sections of the volume exhibit in detail the observations for the positions of these stars, a discussion of the observations by the Method of Least Squares, the resulting catalogue of positions referred to θ Orionis, a comparison of this catalogue with others, particularly Otto Struve's, Sir J. Herschel's, and Liapunoff's, the notes of Prof. Bond accompanying the observations, his original observations on the physical characteristics of the nebula, and a reprint, from the Proceedings of the American Academy, of his paper on its spirality, together with two appendices, one relating to the observations of the elder Bond, and the other to the errors of the equatorial as affecting the micrometrical measurements. With the discussions and explanatory notes of the editor, this volume presents materials of inestimable value to future observers of this nebula, and will contribute largely toward enabling them to settle the various questions relating to changes of form and brightness in this object, and to the variability of the stars in and near it. The latter question is discussed to some extent in the present volume.

Astronomers will await with interest the results of the observations on this and other nebulæ, which it is understood Prof. Safford is engaged in making with the great 18½ inch refractor of the Dearborn Observatory at Chicago, of which institution he is the Director.

His work of editing the volume before us was completed while he was acting director of the Cambridge Observatory, in the interval between the death of Prof. Bond and the accession of the present incumbent, Prof. Winlock.

2. *The Chemical News, and Journal of Physical Science.* American edition. New York, W. A. Townsend & Adams. July and August, 1867. pp. 48 and 60.—The English edition of the Chemical News is well known and justly appreciated in this country. When the republication of it in New York was announced, at a moderate subscription price, we felt that the publishers were doing the cause of science a real service. We have now before us the July and the August numbers. They follow closely their English original, with the important exception that the reprint, instead of appearing weekly, is issued monthly, having four of the English weekly numbers in one. Moreover, instead of giving the numbers consecutively and separately, the articles from each have been rearranged under their respective heads. The July number contains Nos. 387, 388, 389, 390, issued in London May 3, 10, 17 and 24; the August number, Nos. 391, 392, 393, 394, 395, issued May 31, June 7, 14, 21, 28; making a difference in time of two months. Again the parts issued are announced as Vol. I, Nos. 1 and 2, with no mention that they are really a portion of Volume XV, beginning near its middle. It is therefore quite impossible to tell in which of the weekly numbers, any given article was printed; and it is also impossible to find an article in either edition, by a single reference to the other. A reprint should be in every case an exact fac-simile of the original. The publishers state in a letter to the Editors of this Journal, that the preservation of the English dates and paging will "doubtless be hereafter introduced," and we hope that for the benefit of science it may be at once done.

3. *A Treatise on Astronomy, Spherical and Physical*, with Astronomical Problems, and Solar, Lunar, and other Astronomical tables, for the use of Colleges and Scientific Schools; by WILLIAM A. NORTON, M.A., Prof. of Civil Egineering in Yale College. Fourth edit., revised, remodelled and enlarged. 444 pp. text, with 114 pp. additional of tables, and numerous wood-cuts. New York, 1867 (John Wiley & Son).—Professor Norton, as his title page and more fully his preface states, has entirely remodelled his Astronomy, and adapted it thereby to the present state of the science. The chapters on astronomical instruments, comets, the physical constitution of the sun, zodiacal light, and others have been rewritten, and the text generally has been enlarged by the addition of more extended descriptions of astronomical facts, and an account of recent deductions with regard to the physical constitution of the heavenly bodies, and brief expositions of physical theories bearing on the subject, while the more difficult investigations of astronomical formulas occurring in the text of the former edition, have been transferred to the appendix. The work is an excellent college text book, and is rendered especially convenient for the practical astronomer by the mathematical tables, 96 in number, with which it closes.

4. *Elements of Chemistry, Theoretical and Practical;* by WILLIAM ALLEN MILLER, M.D., LL.D., Treas. and V. President Roy. Soc., V. P. Chem. Soc., etc. Part II, *Inorganic Chemistry.* From the 3d London edition. 806 pp., 8vo, with numerous wood-cuts. New York, (John Wiley & Son).—Messrs. Wiley & Son are doing good service to American science in the republication of the excellent work on Chemistry by Prof. Miller. There is no better one in the English language. Professor Miller has combined in his treatise the practical with the theoretical in a way that renders it useful and popular beyond the limits of the ordinary chemical class and lecture room. The volume is handsomely printed, and well illustrated.

5. *A Popular Treatise on Gems in reference to their scientific value, a guide for the teacher of Natural Sciences, the Lapidary, Jeweller, and Amateur, &c.;* by Dr. L. FEUCHTWANGER. 3d edit., 504 pp., 12mo. New York, 1867.—Dr. Feuchtwanger's treatise on gems is a popular work, containing much information of interest to science, the jeweller's art, and the wearers of jewels. It is illustrated by numerous plates, some of them colored, and very naturally so.

6. *Annual of the National Academy of Sciences for* 1866. 154 pp. 12mo.—This volume contains an excellent biographical notice of James Melville Gillis of the Washington Observatory, by B. A. Gould; a second of Benjamin Silliman, by A. Caswell; and a third, not unexceptionable, of Edward Hitchcock, by J. P. Lesley.

7. *Memoirs of the Boston Society of Natural History*, Volume I, Part II.—The following are the contents of this volume.—Page 131, Osteology of the *Colymbus torquatus*, with notes on its myology, with a plate; E. COUES.—p. 173, Zoological relations of the first-discovered traces of Fossil Neuropterous Insects in North America, with remarks on the difference of structure in the wings of living Neuroptera, with a plate; S. H. SCUDDER.—p. 193, On the parallelism between the different stages of life in the individual and those in the entire group of the Molluscous

order Tetrabranchiata; A. HYATT.—p. 210, On the glacial phenomena of Labrador and Maine, with a view of the recent invertebrate Fauna of Labrador; A. S. PACKARD.

8. *Transactions of the American Entomological Society*, Vol. I, No. 1, 120 pp., 8vo, with two colored plates. Philadelphia.—This first number contains (1) Descriptions of American Lepidoptera No. 1, by A. R. Grote and C. T. Robinson; (2) Catalogue of the described Tenthadinidæ and Uroceridæ of N. America, by Edward Norton; (3) Notes on the Pompilidæ of N. America, with descriptions of New Species, by E. T. Cresson.

PROCEEDINGS AMER. ACAD. ARTS AND SCI., Boston, 1866, Vol. VII.—p. 99, On an improved apparatus for the determination of vapor densities; *C. M. Warren.*—p. 103, Biographical notice of Jared Sparks.—p. 135, Comparative qualities of shot and guns; *D. Treadwell.*—p. 143, Enumeration of Hawaiian Plants; *H. Mann.*

ANNALS LYC. NAT. HIST. OF NEW YORK, Oct. Dec. 1866, Vol. VIII, Nos. 13, 14.—p. 351, Lepidopterological Contributions; *A. R. Grote & C. T. Robinson.*—p. 387, Notes on the nat. hist. of the scorpion; *R. Hill.*—p. 394, On some species of W. I. maritime shells in the cabinet of Amherst College; *H. Krebs.*—p. 399, On the classification of the Appredorus gibbosus of LeSueur, and Scolopsis sajanus of J. Gilliams; *T. A. Telkampf.*—p. 400, Descriptions of six new species of birds of the families Hirundinidæ, Formicaridæ, Tyrannidæ and Trochilidæ; *G. N. Lawrence.*

PROCEEDINGS ESSEX INSTITUTE, Vol. V, June, 1867.—p. 57, Fermeyer's Researches, etc., on Silk from Spiders; translated by *B. G. Wilder.*—p. 79, List of birds observed near Hamilton, C. W.—Part II of Naturalist's Directory, North America and the West Indies; Botany.

PROCEEDINGS ACAD. NAT. SCI. OF PHILADELPHIA, 1867, No. 2.—Page 33, Structure of Lopezia; *T. Meehan.*—p. 34, Mammalogical notices; *J. H. Slack.*—p. 39, On Euclastes, a genus of extinct Cheloniidæ; *E. D. Cope.*—p. 42, Dicœcious forms of Vitis vinifera; *T. Meehan.*—New species of Texan Myriapoda; *H. C. Wood.*—p. 44, Two new minerals from Chester Co., Pa.; *I. Lea.*—p. 45, A third study of the Icteridæ; *J. Cassin.*—p. 75, Notes of Micropus leucopterus of Say ("The Chinch Bug"), with an account of the great epidemic disease of 1865 among Insects; *H. Shimer.*

PROCEEDINGS BOSTON SOC. NAT. HIST., Vol. XI.—P. 83, On a sculptured stone from L. Utopia, N. Brunswick; *E. Bicknell.*—p. 89, List of the Birds of St. Domingo, with descriptions of some new species or varieties; *H. Bryant.*—p. 117, On some Fossil insects from the Tertiary of Green river, Colorado; *S. H. Scudder.*—p. 118, On monstrosities observed in wings of Lepidopterous Insects, and how they may be produced; *L. Trouvelot.*—p. 120, On a Fungoid parasite or Caterpillar Fungus, from the Philippine Islands; *S. Kneeland.*—p. 125, Habits of Migratory fishes; *T. Lyman.*

PROCEEDINGS OF THE ENTOMOLOGICAL SOCIETY OF PHILADELPHIA, Vol. VI, 1866-7.—Page 1, Lepidopterological notes, No. 2; *Grote & Robinson.*—pp. 31, 189, On the Pselaphidæ; *E. Brendel.*—pp. 39, 353, Fossorial Hymenoptera of N. America; *A. S. Packard.*—p. 106, Prof. Dana and his Entomological speculations; *B. D. Walsh.*—p. 122, Coloradian Butterflies; *T. Reakirt.*—pp. 152, 335, New N. A. Formicidæ; *S. B. Buckley.*—pp. 173, 287, On the Zygænidæ of Cuba; *A. R. Grote.*—p. 195, On certain N. A. species of Satyrus; *W. H. Edwards.*—p. 200, On certain Diurnal Lepidoptera of the U. S. and British Amer., No. 5; *W. H. Edwards.*—New species of Chrysophanus; *H. Behr.*—p. 209, On certain Entomological speculations—a Review; *A. S. Packard.*—p. 219, Two new N. A. Cecidomyiæ; *Osten Sacken.*—p. 221, Notes on Thyridopteryx ephemeræformis; *B. Clemens.*—p. 223, On the insects of the Galls of certain Willows; *B. D. Walsh.*—pp. 289, 296, Habits of a few Californian Coleoptera; on Usechus lacerta; on Rhadodera tuberculata; and observations on Phodaga alticeps; *G. H. Horn.*—p. 351, New species of Trigonalys; *E. T. Cresson.*—p. 445, Description of new species of N. A. Brachycerous Diptera; *A. R. Grote.*